JOURNAL

OF THE

ELISHA MITCHELL SCIENTIFIC SOCIETY

1898

FIFTEENTH YEAR PART FIRST

JOURNAL

OF THE

Elisha Mitchell Scientific Society

VOLUME XIV ——— PART FIRST

January-June

1898

POST OFFICE
CHAPEL HILL, N. C.

ISSUED FROM THE UNIVERSITY PRESSES
CHAPEL HILL, N. C.

TABLE OF CONTETS.

THE NATURE OF THE CHANGE FROM VIOLET TO GREEN IN SOLUTIONS OF CHROMIUM SALTS.
F. P. Venable and F. W. Miller..... 1

NESTING HABITS OF SOME SOUTHERN BIRDS IN EASTERN NORTH CAROLINA.
T. G. Pearson..... 17

THE DICHOTOMOUS GROUP OF PANICUM IN THE EASTERN UNITED STATES.
W. W. Ashe..... 22

NATURAL SCIENCE OF THE ANCIENTS AS INTERPRETED BY LUCRETIUS.
F. P. Venable..... 62

JOURNAL

OF THE

Elisha Mitchell Scientific Society.

FIFTEENTH YEAR—PART ONE.

1898.

THE NATURE OF THE CHANGE FROM VIOLET TO GREEN IN SOLUTIONS OF CHROMIUM SALTS.

By F. P. Venable and F. W. Miller.

It is a well-known fact that solutions of certain chromium salts which are violet in color become green on heating. This has been especially noticed in the case of the chrome-alums and of the sulphate, but is also true of the nitrate, chloride, and acetate, in fact, of all the soluble compounds of chromium. A reverse reaction also takes place and all of these solutions made green by heating become violet again on standing, the nitrate, chloride, and acetate very rapidly, the sulphate and alums slowly, and often only after prolonged standing. It is quite reasonable to suppose that these changes are caused by similar reactions in the case of various salts, and that there is one explanation for all.

A large number of explanations have been offered by various investigators. In fact it is surprising to find how many have been drawn to investigate these changes and what an amount of work has been done upon them. Perhaps the difficult nature of the problem has been the great source of attraction. Fischer[1] and Jacquelain[2]

[1] Kastner's *Archiv.*, 14, 164.
[2] *Compt. rend.*, 24, 439.

have attributed these changes to a separation of the chromium sulphate from the alkaline sulphate; Berzelius[1] and Fremy[2] assigned as the cause of the changes the formation of a basic sulphate; Recoura and Whitney[3] and Dougal[4] have considered the true cause to be the formation of a chrom-sulphuric acid; Schrötter[5] suggested a partial dehydration, and Etard[6] also thought the change due to an alteration in hydration; Roscoe and Schorlemmer[7] regarded the green solutions as containing mixtures of basic and acid salts; Loewel[8] advanced the theory of an isomeric change.

It is quite manifest that any theory like that of Fischer and Jacquelain, based upon an examination of the alums alone, is quite inadequate. It is further evident that any phenomenon which has aroused so great a variety of speculations as this must be considered very carefully with due weighing of every known fact. These facts are numerous and important.

HOW THE CHANGE MAY BE BROUGHT ABOUT.

Chrome-alum is soluble in six parts of water; the violet solution suffers the alum slowly to crystallize out unchanged by spontaneous evaporation; but if heated to between 50° and 75° it turns green and, according to the extent of decomposition, either deposits on evaporation a brilliant, green, amorphous, difficultly soluble mass, or "yields crystals of sulphate of potash, leaving green sulphate of chromic oxide in solution."[9]

Schrötter says the change takes place at 65°–70°. He

[1] *Ann. Phys. Chem.*, 61, 1.
[2] *Compt. rend.*, 47, 883.
[3] *Ztschr. phys. Chem.*, *1896*, 20, 40.
[4] *J. Chem. Soc.*, Lond., *1896*, 69, 1526.
[5] Pogg. *Ann.*, 53, 513.
[6] *Compt. rend.*, 84, 1090.
[7] Treatise on Chemistry, First Edition, Vol. II, Pt. II, 163.
[8] *J. d. Pharm.* (3), 7, 321.
[9] Fischer, cited in Gmelin: Handbuch, *1850*, IV, 149.

further states that the crystals of potassium sulphate separate only from a highly concentrated solution and in small quantity. Sprung has shown, in experiments to be quoted later, that the change begins at a temperature under 30°.

We have repeatedly attempted to secure the separation of crystals of potassium sulphate as described by Fischer and Schrötter, but without success. The exact conditions are clearly difficult to hit upon, if such a separation is at all possible.

Alkaline hydroxides and carbonates, according to van Cleeff,[1] turn violet solutions of the alums green, and Etard[2] has shown that they bring about the same change in solutions of the normal sulphate. Sulphuric acid, phosphorus trichloride, and nitric acid, according to Etard, bring about the same change, but Otto[3] says that sulphuric acid does not turn solutions of the alum green if rise of temperature is prevented. Schrötter says that nitric acid turns green solutions of chromium sulphate blue again.

Our experiments along this line resulted as follows: First as to the action of acids. Hydrochloric acid had no action upon either violet or green solutions, nor does it apparently have any influence upon the change from one to the other on heating. Sulphuric acid brought about no change in either in the cold, but has a retarding influence upon the change on heating. This was so marked in one or two experiments that it was thought the change would be entirely prevented. Nitric acid had no appreciable immediate effect upon either in the cold. On heating with the violet the retarding action was greater than when sulphuric acid was used, and the solution resumed its violet color on cooling. Acetic acid had

---

[1] *J. prakt. Chem.* (2), 23, 58.
[2] *Compt. rend.*, 84, 1090.
[3] Graham-Otto, 4 Aufl., 3, 113.

apparently no influence. As to the action of alkalies, sodium or potassium, or ammonium hydroxide, or the carbonates, readily turned the violet solutions green. They had no action upon green solutions.

CHANGES IN PHYSICAL PROPERTIES.

In the case of chromic sulphate, Sprung[1] has shown that the violet solution with about twenty-four per cent. of the salt has the specific gravity 1.1619. while the green is 1.1486. So too with the alum there is an increase of volume, which has been noticed by Siewert and also by Mohr,[2] and a decrease of volume is observed as the green solution reverts to the violet. Lecoq de Boisbaudran[3] has also observed these changes, noting that they are independent of the concentration of the solution. the presence of crystals, or whether the vessel is open or closed. The changes in density can be reckoned from his dilatometric observations. Dougal[4] has shown that the alteration in density of even a dilute solution of chrome-alum, after boiling, may readily be detected by a specific gravity bottle. In this manner, one, two and a half, and five per cent. solutions were experimented upon. The actual amount of change depended upon the duration of the heating and the length of time which had elapsed since the green solution had been prepared. The violet solutions became specifically lighter when changed to green by boiling. The transformation is accompanied therefore by expansion.

According to Sprung the violet and green solutions show a difference in internal friction or viscosity. The ratios of diffusion out of capillaries at temperatures 10° 20°, 30°, 40°, 50°, of the green to the violet were as 100

---

[1] *N. Arch. ph. nat.*, 53, 112.
[2] *Ber. d. chem. Ges.*, *4*, 318.
[3] *Compt. rend.*, 79, 1491.
[4] *J. Chem. Soc.* Lond., *1896*, 69, 1597.

to 60.70 ; to 67.77 ; to 68.74 ; to 70.79 ; to 75.72. From this it is seen that the change begins at less than 30°, and from this arises the observation that has been made that the solution of the alum turns somewhat green at ordinary temperatures.

The diffusion of these solutions has also been carefully studied with a view to throwing light upon this puzzling problem.

With regard to the sulphate it has been shown by van Cleeff[1] that green solutions on being dialyzed yield dialysates containing a larger proportion of acids. This had been repeatedly investigated in the case of the alum. Thus van Cleeff has found that in the dialysis of the green solution of the alum, relatively more sulphuric acid goes into the dialysate than when the violet solution is dialyzed. Dougal[2] has also carried out careful experiments along this line. Time, temperature, strength of the dialysate, amount of initial change, amount of retrogression, all affected the results, and little beyond the facts stated above could be deduced from them. The experiments were made upon solutions containing one per cent. of the alum. While the author states that no comparison could justly be made between the experiments, it may be noted that the ratio of increase in acidity was fairly regular and ranged between one-seventh and one-sixth.

A few experiments were undertaken upon the dialysis of the alum before Dougal's experiments were known to us. They were not pushed to completion when these latter became known, especially as there seemed little chance of their throwing much light upon the nature of the change.

CHANGES IN CHEMICAL PROPERTIES.

One of the most singular changes in chemical proper-

---

[1] *J. prakt. Chem.* (2), 23, 58.
[2] *J. Chem. Soc.* Lond., *1896*, 69, 1527.

ties is that noted in the action of the sulphate or alum, before and after heating, upon solutions of barium or lead salts. This was first observed by Loewel[1] and was studied by Favre and Valson.[2] A violet solution on being treated in the cold with a solution of barium chloride, yields practically all of its sulphuric acid as barium sulphate. A cold green solution forms a precipitate slowly, and even after a number of hours the precipitation is far from complete. On boiling, all of the sulphuric acid will be precipitated. Favre and Valson found that only one-third of the sulphuric acid present in the original chromic sulphate was precipitated in the cold by the barium chloride.

Our own experiments upon this point were as follows: A weighed amount of the pure alum was dissolved and the solution made up to a definite quantity. Two aliquot portions were taken, one of which was heated for half an hour and allowed to cool. Then both portions were precipitated with an excess of barium chloride. It was found impossible to filter these immediately with asbestos felts or the best filter-paper. They were therefore allowed to stand about twenty-four hours. This very long standing probably changed the conditions somewhat, but we were unable to avoid it. Still the results would confirm the observations of Favre and Valson. The prolonged standing also showed that it was not merely a delayed precipitation, but one partially prevented.

	I.	II.
Percentage of SO_3 in alum is 32.06.....	....	....
Percentage of SO_3 in alum, violet solution precipitated cold.....	30.44	30.19
Percentage of SO_3 in alum, green solution heated one-half hour.....	22.78	22.33
Percentage of SO_3 in alum, green solution heated one hour.....	22.87	21.83

[1] *J. Pharm.* (3), 4, 32.
[2] *Compt. rend.*, 77, 803.

These experiments were upon solutions containing one gram to 100 cc. A solution twice as strong was next taken:

	I.	II.
Percentage in violet solution precipitated cold	28.88	31.80
Percentage in green solution (heated one hour) precipitated cold	19.55	21.47

Again a solution containing 0.5 gram to the 100 cc. was taken.

Percentage in violet solution precipitated cold	28.30
Percentage in green solution (heated one hour) precipitated cold	23.00

The difficulties of washing and filtering barium sulphate precipitated in this manner account in part for the lack of agreement between the analyses, but two things are evident; first, that all the sulphuric acid is not precipitated from either violet or green solutions in the cold, and, secondly, that a short boiling effects such a change that only two-thirds of the sulphuric acid is precipitated by barium chloride in the cold. The amount not precipitated ranged from 9.06 to 13.51 per cent.

Many observations have been recorded as to the acidity of the violet and green solutions of the alum. Recoura[1] has stated that the vapors coming from a solution at 100° are acid, while the solid salt at the same temperature does not lose any acid. He further maintains that the green solution, left after the heating, contains a considerable amount of free acid. He made use of the heat of neutralization as a means of measuring the degree of acidity. A known amount of soda was added to the liquid and the heat liberated was measured. In so far as this corresponds with the heat liberated by the neutralization of free sulphuric acid in the same degree of dilution, he concluded that he was dealing with free acid. According to his

1 *Compt. rend.*, 112, 1440.
2 *Ann. Phys. Chem.* (3) 61, 218.

experiments there was one-half of an equivalent of sulphuric acid for every equivalent of chromium sulphate.

It was Kruger[1] who first attempted to show in 1844 the presence of free sulphuric acid in the green solution. He thought this was proved by the acidity of the layer of alcohol poured over the green solution.

Baubigny and Pechard[2] have shown that the alum has always an acid reaction even after purification by means of alcohol. Further they regarded the following experiment as proving a partial dissociation of the salt. To twenty cc. of a saturated solution of the alum, three-tenths gram of ammonia gas was added, and, after shaking, the liquid was neutral to methyl orange; after some time the liquid which had become green on the addition of the ammonia, yielded violet crystals with strong acid-reaction and the mother-liquor had become acid to methyl orange.

Whitney[1] has also attempted to prove the presence of acid by physical methods. Sodium hydroxide and barium hydroxide respectively were added to the green solution. The addition of a base must lower the conductivity of the solution as long as free sulphuric acid is being neutralized. He found the minimum when he had added one-sixth of an equivalent of sodium hydroxide to the chromium sulphate, or one-third of an equivalent of barium hydroxide. No explanation was given of the variation in the results. He also claimed to have proved the presence of free acid by the catalysis of methyl acetate. Lastly, the inverting action of green solutions of chromium chloride, acetate, nitrate, and sulphate was tried upon sugar solutions. He came to the conclusion that in the case of the chloride and nitrate, two-thirds of the acid was set free on boiling; of the acetate more than two-thirds, and of the sulphate less than one third. In our own experiments as to the relative

1 *Compt. rend.*, 115, 604.
2 *Ztschr. phys. Chem.*, 1896, 20, 40.

acidity of the violet and green solutions, it was seen that both solutions were acid. We tried a large number of the usual indicators, but the violet and green colors of the solutions interfered too much to give any results with them which could be regarded as at all satisfactory. It was found that fair results could be obtained by using a decinormal solution of ammonia and noting the first appearance of a permanent precipitate.

	Tenth-normal ammonia.
	cc.
One gram in 100 cc. cold required	27.5
" " " " " boiled one-half hour	27.6
" " " " " " one hour	26.5
" " " " " " two hours	26.5

During the boiling, the water evaporated was repeatedly restored. Unless this was done a little acid was lost, and even with this precaution there was a small loss, and this may explain the acidity of the vapors coming off at at 100° as observed by Recoaru.

The experiments therefore agree with those of Baubigny and Pechard, but are at variance with the conclusions of the other authors mentioned. We think the experimental data of these authors do not afford sufficient and satisfactory evidence to serve as a basis for their conclusions that free sulphuric acid exists in the solution. The methods adopted are very indirect and the results capable of other explanations.

THE EXISTENCE OF CHROMO-SULPHURIC ACIDS.

Several articles have been published by Recoura[1] upon chromo-sulphuric acids. He claims to have prepared several of these and regards the formation of such bodies as a probable explanation of the change in the green solutions, and others, as Whitney and Dougal, seem to accept his explanation. Recoura thinks there are two isomeric modifications of chromium sulphate; one violet, one green, and also another green sulphate not isomeric,

but basic ($2Cr_2O_3.5SO_3$). These he refers to three conditions of chromic hydroxide: $Cr_2(OH)_6$, precipitated by alkalies from violet chromic salts; $Cr_4O(OH)_{10}$, corresponding to the basic sulphate and non-isolable; $Cr_2O(OH)_4$, precipitated by alkalies from green solutions. Solutions of this latter in acids, he says, are not precipitated by solutions of barium salts. This last statement is not strictly true. Such solutions are partially precipitated by barium salts just as all green solutions are. He assigns to the green sulphate the formula $Cr_2O_3.3SO_3.11H_2O$, which he says has quite a different constitution from that of the violet sulphate. Proofs for this statement he does not give. This isomeric green sulphate, he says, possesses neither the characteristics of a sulphate nor of a chromium salt. One molecule can combine with one molecule of either sulphuric acid or a metallic sulphate. Thus we may have $Cr_2(SO_4)_3.H_2SO_4$, or $Cr_2(SO_4)_3.K_2SO_4$. In these compounds all the sulphuric acid is in a non-precipitable form, he maintains. His crucial experiment is as follows:

"Mix a solution containing one molecule of $Cr_2(SO_3)_4$ with a solution containing one molecule of sulphuric acid or a sulphate. Union is immediate, for barium chloride will now give no precipitate and the solution therefore holds no sulphate. The new radical is unstable, for precipitation is immediate on boiling, or in concentrated solutions or in dilute solutions on standing one-half hour. *It is necessary to work with very dilute solutions, otherwise the radical containing chromium is decomposed.*"

Of course such reasoning would give us these same strange isomeric metal-sulphuric acids in all sulphates, for if they are diluted enough it will take half an hour or more for the precipitate to form with barium chloride.

On such slender basis Recoura builds up a series of salts of a hypothetical chromo-sulphuric acid $(Cr_2.4SO_4)_2$.

---

1 *Compt., rend.*, 113, 1037; 114, 477; 116, 1367.

He has also prepared a chromo-disulphuric acid, etc., by evaporating solutions of chromium sulphate with two, three, etc., molecules of sulphuric acid, and then heating to 110°–120°. Calvert and Ewart[1] have shown that, on diluting these, they all leave a colloidal $Cr_2(SO_4)_3.H_2SO_4$ upon the septum, the liquid passing through free of chromium. The behavior of these solutions makes it appear probable that the chromo sulphuric acids do not exist in them as such, but are hydrolyzed, forming the colloidal substance, $Cr_2(SO_4)_3.H_2SO_4$, and free sulphuric acid. Our repeated experiments have failed to show the presence of this colloidal body in the ordinary green solutions of the alum or sulphate. A boiled solution of either, even though very concentrated, will pass entirely through an unglazed porcelain suction filter, such as Calvert and Ewart made use of. There seems to be no colloidal body present.

We cannot regard the experiments of Recoura as advancing the subject in any degree. As an explanation of the changes it is by no means satisfactory. Dougal's formula for the reaction causing the change, is even more remarkable and baseless :

$$2[Cr_2(SO_4)_3.K_2SO_4]+H_2O = [Cr_4O(SO_4)_4]SO_4 + 2K_2SO_4+ H_2SO_4.$$

This is not based upon Dougal's own experimonts but is offered as an explanation deduced from the work of Recoura, Whitney, Favre, and Valson.

THE ACTION OF ALCOHOL.

There have been several investigations of the action of alcohol, both upon the sulphate and the alum, with the hope of throwing some light upon the changes under consideration. Traube[2] states that the solid salt is unaffected by boiling alcohol. Schrötter has observed[3] that

1 *Chem. News.* 74, 121.
2 *Hnn. Chem.* (Liebig), 66, 168.
3 Pogg. *Ann.*, 53, 413.

solutions covered with a layer of alcohol become gradually green and the concentrated green solution is not dissolved by alcohol. Of course the first observation does not necessarily connect the alcohol with the change. Alcohol in large amounts precipitates from violet solutions of the sulphate a pale violet colored, crystalline powder, and decolorizes the liquid.[1] This can be used as a mode of purifying the alum.[2] Siewert[3] states that, when the violet sulphate is dissolved in a small amount of water and boiled with alcohol until the crystals formed are again taken up and then precipitated with ether, a green syrup is gotten which consists of $5Cr_2O_3 12SO_3 . xH_2O$ and the mother-liquor contains sulphuric acid in a condition in which it is not precipitated by barium chloride. Krüger[4] states that alcohol precipitates from a green solution of the alum a green oil which solidifies and which contains only two-thirds of the sulphuric acid. Siewert confirms this and says that this substance has approximately the composition $6K_2O.5Cr_2O_3.18SO_3.H_2O$. Krüger mentioned the acidity of the alcohol used in precipitating the green oily liquid and evidently regarded it as withdrawing sulphuric acid from the original salt. He also mentioned the formation of a basic salt, by heating the green solution until it becomes rose-red, which contains half as much acid as the neutral salt and is insoluble in water.

After a careful consideration of the results obtained by others by means of alcohol, it seemed to us quite possible that these might afford a clue to the explanation we were in search of. It was necessary to examine with care the action upon both the violet and the green solutions. Our experiments are therefore given in detail, and it will be

1 Gmelin's Handuch, IV, 127.
2 Baugigny and Pechard: *Loc. cit.*
3 *Ann. Chem.* (Liebig), 125, 97.
4 *Ann. Phys. Chem.*, 61, 318.

seen that they agree in part only with the observations just quoted.

Action on the Violet Solution.—When alcohol was added to the violet solution of alum, fine violet crystals were precipitated, which gave on analysis the following results:

	Calculated for $K_2Cr_2(SO_4)_4.12H_2O$.	Found. I.	II.
Cr	13.32	13.68	13.36
K	9.99	9.80	....
SO_4	49.99	48.85	....

This may be an old observation that on crystallizing from alcohol the crystals contain only half the usual amount of water, but we have not met with it anywhere. The fact that this very considerable change of hydration effects no change in color nor in the precipitating power of barium chloride, argues against the partial dehydration theory of Schrötter and Etard. It should be added that the precipitation was carried out with absolute alcohol upon concentrated solutions of the alum, was rapid, and the precipitate was immediately removed. There seemed to be two layers of crystals, one of violet crystals (upper) and the other a heliotrope powder. Analysis showed that the composition of both was the same and that the difference was probably one of subdivision. The precipitation is almost complete, as the alcohol shows very little color. From this it is evident that alcohol itself does not materially affect the violet solutions.

Action on the Green Solutions.—Green solutions of the alum were first experimented with. When absolute alcohol is added to concentrated solutions of chrome alum, which have been boiled until green and allowed to cool, a dark green gummy mass separates out after a short time. If the boiling is not sufficiently prolonged there will form afterwards a few violet crystals. The alcohol retains something in solution, as is shown by the green color. This amount retained may be considerable if much water

is present. It would seem then, that alcohol precipitates out the body and makes it available for analysis and examination. If a portion of this green, gummy mass is taken and dissolved in water, it exhibits the same behavior towards barium chloride as has been observed in the green solutions. In one or two cases it was observed that the part remaining dissolved in the alcohol yielded practically all of its sulphuric acid to barium chloride in the cold. The green mass was thoroughly washed with alcohol and dried over sulphuric acid. It also dries to a brittle mass if exposed in thin layers to the atmosphere. It is quite insoluble in alcohol, but soluble in water. A number of preparations of this substance were made and analyzed and the results are in such agreement that one is inclined to believe that the substance is a definite compound.

Fifteen grams of chrome alum were dissolved in 100 cc. water and boiled for one hour to a concentration of fifty cc. This was cooled and precipitated by the addition of 100 cc. of absolute alcohol. The green mass obtained on drying weighed about eight grams. This was carefully analyzed :

	Calculated for $7K_2SO_4.5Cr_2(SO_4)_3Cr_2(OH)_6.4H_2O$.	Found. I.	II.	III.	IV.
Cr	18.07	18.23	18.32	18.02	17.76
K	15.88	15.18	15.63	15.78	....
SO_4	61.08	60.55	60.73	....	60.79

Analysis III and IV were from other preparations, made, however, in a similar manner to that just described. This substance appears to have quite a complicated constitution, and it is not easy to see the part played by the potassium sulphate. It do esnot seem to be a matter of accidental occurrence, however. The important feature is that the salt is a basic one. Siewert gives, as the result of his analysis, $6K_2O.5Cr_2O_3.18SO_3.H_2O$, for which the following percentages would be required: Cr, 18.7 ; K, 16.8 ; SO_4, 61.9. While these percentages differ somewhat from those obtained by us, the agreement is suffi-

cently close to show that the substances examined were practically the same.

On concentrating the liquid poured off from the green gum, it was repeatedly observed that more of the gum was obtained. For instance, in the experiment described where the green mass from fifteen grams weighed about eight grams, a further portion weighing 0.3915 gram was gotten. The analysis of this yielded the following percentages: Cr, 13.66; K, 8.57; and SO_4, 55.45. We could only regard this as a mixture consisting in part of the green basic mass which had not completely separated out. The small amount of material left in solution (less than one-half gram) consisted of a little chromium with sulphuric acid in the ratio of about five to one.

Next the action on chromium sulphate was examined. The chromium sulphate used was in the form of small violet scales or crystals. It was a commercial product and the method of its preparation was unknown to us. An analysis of it gave:

Cr	22.10.
SO_4	44.20.

It is therefore a basic chromate, but we have seen no such body described in the books. It dissolved in water with a green color. Fifteen grams of this dissolved in 100 cc. of water, boiled to a concentration of 50 cc. and precipitated with 100 cc. of alcohol, yielded about ten grams of the green, gummy mass, very similar in appearance to that obtained from the alum, but more soluble in alcohol. In a second experiment twelve grams were taken and treated in the same way, and yielded about eight grams. The analysis showed these to be identical.

	Calculated for $Cr_2(SO_4)_3.Cr_2(OH)_6.15H_2O$.	Found. I.	II.	III.
Cr	24.06	22.41	22.40	22.69
SO_4	33.17	34.64	34.73	34.43
Water	43.77	....	....	....

The agreement is far from satisfactory, but the body is evidently a basic salt.

On evaporating the liquid portions other masses were obtained. These were also analyzed:

Calculated for $2Cr_2(SO_4)_3.Cr_2(OH)_6.20H_2O$		Found.	
	I.	II.	III.
Cr.....22.70	22.93	22.71	22.98
SO_4.....42.72	42.72	43.32	43.46
Water.....34.57	....	....	....

This is less basic than the previous compound. As the alcohol left is decidedly acid, it must contain either free acid or an acid sulphate.

It did not seem to be necessary to prepare other chromium sulphates, as these experiments were in accord with those obtained with the alum, and lack of time made it necessary to bring the experiments to an end.

CONCLUSIONS.

On weighing the experimental evidence which has been brought to bear upon these changes, it is an easy matter to exclude some of the explanations offered. Thus the dissociation of the alum into chromium and potassium sulphates and similar theories which will not cover the cases of the nitrates, chlorides, etc., must of course be dropped. The formation of chromo-sulphuric acid, as suggested by Recoura, is not tenable in the light of the experiments performed. The theory of the change of hydration is not satisfactory, since it has been seen that a loss of one-half the water did not bring about the change of color.

The theory of Berzelius, however of the formation of basic salts of chromium which would naturally be green and uncrystallizable, offers a full and sufficient explanation of the changes, and is in accord with the observations so far as they have been verified by us. It accounts quite plausibly for the partial withholding of the sulphuric acid from precitation by barium chloride in the cold, and is strongly confirmed by the experiments with alcohol. This theory is also in accord with the facts that

the green coloration may be brought about by the addition of alkaline substances, and that it is retarded by the addition of sulphuric or nitric acid. It is also easy to apply this explanation to the cases of the nitrate, chloride, acetate, and soluble compounds of chromium. When we have opportunity we propose examining the action of alcohol upon these other compounds.

NESTING HABITS OF SOME SOUTHERN FORMS OF BIRDS IN EASTERN NORTH CAROLINA.

T. GILBERT PEARSON.

The coastal region of North Carolina, especially south of Hatteras, having its temperature moderated by warmer ocean currents affords many interesting forms of life both in the fauna and flora whose natural habitat would naturally be looked for at a much more southern point. Thus the palmetto (*Sabal palmetto*) which grows wild to a height of 30 feet on Smith's Island is also found in a more stunted form as far north as the banks of Cape Hatteras. This northward extension of the habitat of some Southern birds is somewhat in keeping with that of the flora.

While spending some time in eastern North Carolina during the past summer I observed there some species of southern birds which have hitherto been overlooked by ornithologists as occuring within the limits of this State; and my purpose in publishing the following notes is to record such of these observations as may be of interest.

Worthington's Marsh Wren.[1] (*Cistothorus palustris griscus*).

The range of this bird as given by Mr. Brewster[1] and later by Frank M. Chapman in his "Handbook of Birds of Eastern North America" is the "Coast of South Carolina and Georgia." In the marsh on Gull Island in Pamlico sound about twenty miles north of Cape Hatteras marsh wrens were found in great numbers on May 20th. The island which is approximately two hundred acres in extent is little more than a continuous salt marsh over the greater part of which the water rises at high storm tides. At the time of my visit the birds were in full song and from every side of the marsh came the notes of scores of birds. While singing the performers usually occupied positions entirely out of sight except as occasionally they would make short flights upward and burst into song as they dropped back again into the cover of the high thick grass.

It was evidently too early in the season for the birds to be breeding for, of the twelve nests found and examined, there were none that contained either eggs or young. The nests were suspended among the grass stalks at distances varying from sixteen to twenty inches above the ground or shallow waters. They were entirely roofed over and varied in form from almost round to elliptical. They were composed of the dead stems and blades of marsh grass neatly wound and woven together while the material was yet damp, thus forming a strong and very durable structure. The entrance was a small opening in

---

[1] This new variety was described by William Brewster in the Auk for July 1893, Vol. 10, pp. 215-219.

It differs from the species *C. palustris* mainly in having the black of the upper parts duller and less extended, brown of the sides, flanks and upper parts much paler and grayish, and the dark markings of the under parts confused and inconspicuous.

the side near the top of the nest.[1]

A specimen taken at this time was identified by Mr. C. S. Brimley, of Raleigh, N. C. as being a Worthington's Marsh Wren.

On June the 9th I heard wrens singing in the marshes near Southport which I took to be of this species but as no specimens were secured I shall not claim this as a record.

During July and the early part of August wrens were frequently heard in the salt marshes about Beaufort harbor. A visit to some of the marshes on August the 2nd resulted in the finding of a few empty nests and securing after much labor a single specimen. Wishing to be certain as to the identification of this the skin was sent to Prof. Ridgway of the Smithsomiam Institution who identified it as being a fair type of *C. p. griseus*.

This race will probably be found subsequently to be a common summer resident in suitable localities along the entire North Carolina coast.

Florida Cormorant, (*Phalacrocorax piliphus floridanus*). While Florida is the typical home of these Cormorants it has long been known that in the summer they occur along the Atlantic coast as far north as North Carolina. They have not been recorded as breeding in this State, however, as far as I have been able to learn.

Following the course suggested by numerous rumors, I penetrated the forests and swamps of Craven Co. for a distance of about eighteen miles south of Newbern and found on the 25th. of May, a colony of these birds breeding around the shores of Big Lake. The nests were located on the spreading branches of staunted cypress

[1] A typical nest shows the following external measurements, length from bottom to top 5, in. Depth, 4.25 in. Width, 3.75 in. Entrance to nest, 0.85 in. by 1.12 in. The wall of the nest varies from 0.25 to 0.50 inch.

trees standing in the water from fifty to two hundred yards from the shore. Eighteen trees were thus occupied, the number of nests each tree bore varying from one to twelve. In one tree however there were thirty-eight occupied nests.

The colony was scattered along the lake side for a distance of a mile and a half. The eggs or young contained in each nest varied from two or four in number. In color the eggs are a pale bluish white overlaid with a more or less soft calcareous coating, and measure about two and a half inches in length by one and a half in width.[1]

The young birds were covered with black down, many of them being large enough to leave their nests and climb about on the branches of the trees. In doing this they would often lose their balance on the limbs while endeavoring to escape, but instead of falling into the water the hook at the point of the long bill would invariably catch on the perch and by dint of much scratching the birds would soon regain their former position. So well could they use their bills for climbing that Mr. H. H. Brimley of Raleigh N. C. to whom some of these were sent remarked afterwards in a letter that they repeatedly climbed with apparent ease up the wire netting which composed the sides of their cage.

The food of the cormorants at this season of the year must consist largely of eels, (*Anquilla anquilla*). In

[1] The exact measurements in inches and hundredths of two sets of eggs selected at random are here given: A set of four eggs measured 2.50x1.56;2.53x1.62;2.47x1.53 and 2.50x1.56. A set of three showed somewhat smaller dimensions, 2.32x1.56;2.32x1.32 and 2.24x1.53, the average for the seven specimens being 2.42x1.55. Chapman makes no distinction in measurements between the eggs of this variety and the species from which it is derived, giving the measurements of the latter as 2.40x1.40. It is quite possible however that measurements taken from a much larger series of eggs of the Carolina bird might show quite a different result from the above.

nearly every nest signs of eels remains were seen, the young birds upon becoming excited would disgorge fragments of eels. The old birds which were taken usually had the slime of eels about their heads, necks and bills.

The trees, which contained each a number of nests, were completely covered, trunk, limbs, twigs, and nests, with a white coating caused by the fishy excrement of the birds. So white and marked an aspect did the trees present that although they were not usually over twelve or fifteen feet in height their outline could clearly be made out against the dark background of the cypress swamp as we passed in our canoe along the south side of the lake five miles away.

On Jones' mill pond near Newport, Carteret Co., cormorants were commonly reported to breed, but a search of the region failed to reveal any colony. This location is nevertheless evidently a popular roosting resort. A little before sundown on the day I visited it cormorants began to come in over the swamp and in a short time two or three hundred individuals had gathered in the cypress trees along the shores of the pond.

Anhinga, Water Turkey, (*Anhinga anhinga*). This is another bird which we may now add to the list of the *avifauna* of North Carolina. It is a bird of a tropical and subtropical America and has been known to breed as far north as South Carolina.

In damming up a stream on the Orton rice-plantation in Brunswick Co. fifteen miles below Wilmington, a pond was formed which extends back into the woods among the higher ridges for several miles. At the upper end of one of these narrow tongues of water is located a colony of some four or five hundred pairs of herons, which each year assemble to breed in the cypress trees.

While approaching this heronry on the 7th of June an anhinga was flushed from its nest in a small cypress tree about ten feet above the water. It flew rapidly

away but soon returned and was secured a few minutes later upon alighting near the nest. It proved to be a male in magnificent plumage. One other bird, also a male, was seen in the neighborhood but no other nests were noticed. The nest examined was a heavy structure of sticks and twigs lined with long gray moss (*Tillandsia usneoids*). It contained four eggs well advanced in incubation. In appearance they very much resesembled the eggs of the cormorant but are smaller, an average egg measuring 1.15x135.[1] In the neighborhood of Lake Waccamaw and the region south and east of there I occasionally heard mention of this bird from the inhabitants and do not doubt but that in suitable localities throughout the south-eastern part of North Carolina the Anhinga is a frequent summer resident.

[1] Chapman's Handbook of Birds of Eastern North America, 1897, p. 93.

THE DICHOTOMOUS GROUP OF PANICUM IN THE EASTERN UNITED STATES.

1) CONTRIBUTION FROM MY HERBARIUM. No. III.

W. W. ASHE.

The dichotomous section of *Panicum* presents a great difficulty to satisfactory segregation in the confusing and often nearly similar forms acquired not only by nearly related, but even quite dissimilar species in the later, branched condition which the simple primary culm generally assumes after the expansion of its panicle, and sometimes even preceding its expansion. The following descriptions are based on the character of the simple

[1] Issued Nov. 10th, 1898.

state and until one is familiar with the summer and autumnal forms assumed by different types in the group the simple state is necessary in order to make a satisfactory determination. Habit, also, is a character of great value in making determinations in this group, with specimens in either the simple or branched states; and habit should always be noted when specimens are secured. The leaves on the branches are much smaller than the primary leaves, the panicles are much smaller, and the spikelets are generally smaller and more acute. The limitations of the species are, in practically all cases, sharply defined and there are no intergradent forms.

Several of the species proposed by Lamarck, Michaux, Muhlenburg and Elliott are yet subjects of dispute or even speculation, being represented by no type specimens, while the descriptions are not sufficiently minute for accurate determination. I have been able to examine the material in the Herbarium of the Philadelphia Academy of Natural Science, which contains many specimens of Nuttall, Schweinitz, Muhlenburg, and Baldwin. The specimens of Muhlenburg and Baldwin are of particular interest; those of Muhlenburg sometimes representing his own species; while Baldwin's often indicate Elliott's, since he furnished Elliott with many specimens from Georgia. I have, besides, been able to do considerable field work in the region from which Elliott derived his material, central and southern Georgia and eastern Carolina, and have there studied the species with the view of identifying some of Elliott's species. I have found nothing so far, however, which agrees with the description of his *Panicum ovale, P. pauciflorum or P. strigosum.*

The group of the genus that I have designated as the dichotomous group is best developed, so far as number of species is concerned, in the south Atlantic States, probably in eastern South Carolina, or eastern Georgia, where the number of known species will probably amount

to thirty. This paper is only intended to cover the region between northern Florida and Indian Territory, and Minnesota and Maine. The dichotomous group can be characterized as follows:

Basal leaves different from those of the stem, broader, and generally shorter (except in a few species); spikelets all pedicelled, not racemose on the branches, neither gibbous at base, awned, or warty. Stems erect, prostrate, or decumbent, at first simple, later (except in a few species) dichotomously or fasciculately branched, producing on the branches smaller leaves and smaller panicles.

In the following paper seventy-four species are enumerated, but the real number is probably even in excess of this.

KEY TO THE EASTERN DICHOTOMOUS SPECIES OF PANICUM.

(' = one inch. " = one twelfth of an inch. = one foot.)

Leaves lanceolate or ovate-lanceolate, clasping by a broadly cordate base spikelets 1¼" long or more; ligule a mere margin.

Largest leaves about 1' wide, panicle spreading.

Spikelets obovate, over 1½" long.

Nodes barbed ..... 1. P. Porterianum.

Nodes glabrous ..... 2. P. macrocarpon.

Spikelets elliptical, 1¼" long

Leaves ovate-lanceolate, 2' - 3' long, ciliate, sheaths soft-pubescent ..... 3. P. commelinaefolium.

Leaves lanceolate, 3' long or more, sheaths papillose-hispid ..... 4. P. clandestinum.

Largest leaves narrower, 5"—8" wide, ligule none.

Spikelets 1¼" long.

Stems erect, sheaths clasping ..... 5. P. commutatum.

Stems decumbent or ascending, sheaths loose 6. P. Joorii.

Spikelets 1¾" long, elliptical, plant decumbent 7. P. Manatense.

Leaves rounded at base, lanceolate or narrower, 4"—8" wide, spikelets over 1¼" long.

Branches of panicle erect, leaves glabrous, ligule none.

Sheaths sparingly papillose-hispid .... 8. P. xanthophysum.

Sheaths glabrous ..... 9. P. calliphyllum.

Branches of panicle spreading, ligule pilose.

Panicle 3'—5' long, spikelets elliptical, numerous 10. P. scabriusculum.

Panicle 2'—3' long, branches and obovate spikelets few, leaves pubescent ..... 11. P. scoparium.

Leaves narrower, 3"—5" wide, somewhat rounded at the base, spikelets 1¼"—2" long.

Ligule pilose.

Nodes barbed .....12. P. malacophyllum.

Nodes not barbed, sheaths pubescent.

Branches of panicle erect or ascending, leaves spreading ..... 13. P. malacon.

Branches of panicle ascending, leaves erect 14. P. Liebergii.

Branches of panicle spreading ... 15. P. Scribnerianum.

Ligule, nodes and sheaths glabrous.

Spikelets elliptical, 1½" long, leaves 3'—5' long 16. P. equilaterale.

Spikelets 1¼" long, leaves about 2' long.

Leaves spreading, stem nearly naked below 17. P. Ashei.

Leaves ascending, stem leafy below 18. P. Webberianum.

Leaves erect, 2"—3" wide, somewhat rounded at the base, pubescent, at least the lower ones, spikelets broadly elliptical, 1¼"—1½" long.

Stem erect, strict, leaves not crowded (western) 19. P. Wilcoxianum.

Stems much branched from the base, diffuse (southern) 20. P. Georgianum.

Leaves 3"—10" wide, lanceolate, erect or ascending, clasping by a cordate, ciliate base; lower sheaths overlapping, longer than the internodes; spikelets small, ⅞" long or less, nearly spherical, numerous.

Leaves 6"—10" wide, ascending ..... 21. P. polyanthes.

Leaves 4"—6" wide.

Leaves ascending, spikelets ⅞" long .. 22. P. sphaerocarpon.

Leaves erect: spikelets scarcely ½" long 23. P. erectifolium.

Leaves scattered on the stem, linear-lanceolate or longer, erect, 1"—5" wide, all except the lowest narrowed to the base; branches of panicle ascending or at length spreading; spikelets 1"—1½" long, very strongly nerved, nodes not barbed.

Upper leaves not over 3" wide, middle leaves longest.

Spikelets broadly obovate.

Pubescence ascending, rigid ..... 24. P. Addisonii.

Pubescence, if present, villous, spikelets nearly 1¼" long ..... 25. P. consanguineum.

Glabrous or nearly so, spikelets 1" long 26. P. neuranthum

Spikelets elliptical, acute ..... 27. P. angustifolium.

Upper leaves 3"—5" wide, much longer than the lower 28. P. Bicknellii.

Low, densely tufted; leaves linear, 1"—2" wide, erect, crowded near the base of stems, upper not reduced, narrowed to the base; branches of panicle erect or ascending; spikelets broadly elliptical or obovate, 1" or more long, nodes not barbed.

Spikelets obovate, over 1½" long, second and third scales much longer than the fourth ..... 29. P. depauperatum.

Spikelets elliptical, second, third and fourth scales equal.

Spikelets 1"—1¼" long, basal secondary panicles developed ..... 30. P. linearifolium.
Spikelets barely 1" long, no basal panicles developed 31. P. Werneri.

Leaves narrowed to the base, lanceolate or narrower, spikelets 1¼"—1½" long, plant nearly glabrous, lower nodes barbed 32. P. nemopanthum.

Stems simple at length fasciculately branched erect, or sometimes prostrate, stem leaves numerous, scattered, spreading or ascending, lanceolate, 1½"—8" wide, clasping by a rounded or narrowed base, the upper generally not conspicuously reduced in size, and never elongated, the basal usually shorter than those of the stem; spikelets less than 1¼" long.

Nearly or quite glabrous species without a long hairy ligule.

Nodes not barbed, spikelets ¾"—1" long.

Plant strict, erect.

Leaves spreading, narrowed to the smooth base 33. P. dichotomum.

Leaves ascending.

Base of leaves narrowed, rounded, ciliate, sheaths not spotted ..... 34. P. boreale.
Leaves narrowed to the glabrous base, sheaths spotted ..... 35. P. maculatum.

Plant rising from a geniculate base.

Leaves 3'—4' long, ... 36. P. Roanokense.
Leaves less than 1½' long ..... 37. P. demissum.

Nodes barbed.

Spikelets 1" long ..... 38. P. Mattamusketense.
Spikelets ¾" long ..... 39. P. barbulatum.

Nodes not barbed, spikelets less than ¾" long.

Strict, not prostrate or reclining; 8'—16' high.

Leaves 1"—3" wide, with a firm, white margin 40. P. ensifolium.

Leaves 1" wide or less, densely tufted.

Branched only from the base ... 41. P. Baldwinii.
Much branched towards top of culm ..... 42. P. Wrightianum.

Stems at first erect, at length elongated and reclining, spikelets obovate, ¾" long ..... 43. P. sphagnicolum.
Stems prostrate, spikelets broadly elliptical ¾" long 44. P. lucidum.

Stems ascending or reclining, spikelets narrowly elliptical, 3-5" long ..... 45. P. Cuthbertii.

Nearly or quite glabrous species with a long pilose ligule.

Spikelets ½" long or less.

Spikelets about ½" long ..... 46. P. parvispiculatum.

Spikelets scarcely ⅓" long ..... 47. P. leucothrix.
Spikelets ¾"—1" long, obovate.
Panicle oblong, its branches erect or ascending ..... 48. P. Eatonii.
Panicle broadly ovate, its branches spreading.
Leaves erect, panicle 1½' long or less 49. P. Columbianum.
Leaves ascending, panicle 1'—3' long .... 50. P. nitidum.
Sheaths more or less pubescent and often stems and leaves.
Leaves 4"—8" wide, spikelets ¾"—1¼" long.
Strict, 2ft.—3ft tall, pubescence villous .. 51. P. Huachucae.
Stems ascending, geniculate at base.
Pubescence pilose, velvety, spikelets oval 1⅛" long 52. P. viscidum.
Pubescence villous, ascending, spikelets obovate, 1" long ..... 53. P. ciliiferum.
Stems erect, at length decumbent, leaves appressed pubescent beneath.
Spikelets ⅜" long, leaves, ascending 54. P. tsugetorum.
Spikelets ¾" long, leaves spreading 55 P. Tennesseense.
Leaves 2"—4" wide, spreading or ascending, spikelets about 1" long.
Lower branches of panicle ascending, pubescence hirsute-papillose .....56. P. Atlanticum.
Lower branches of panicle spreading.
Strict, leaves spreading, basal leaves not prominent.
Pubescence rough, ascending, spikelets nearly spherical or broadly elliptical ..... 57. P. scoparioide.
Pubescence, villous, long, spreading spikelets elliptic ..... 58. P. villosissimum.
Pubescence softer, ascending spikelets elliptic 59. P. pubescens.
Strict; leaves erect or ascending.
Leaves lanceolate, panicle as broad as long.
Pubescence ascending-appressed .... 60. P. Commonsianum.
Pubescence ascending or spreadiug ..... 61. P. haemacarpon.
Leaves linear-lanceolate, panicle oblong ..... 62. P. arenicolum.
Tufted, stems soon reclining, few-leaved, basal leaves very numerous and long ..... 63. P. laxiflorum.
Leaves 2"—4" wide, spikelets ¾"—⅞" long.
Lower branches of panicle ascending 64. P. lanuginosum.
Lower branches of panicle wide-spreading.
Sheaths papillose-hirsute ..... 65. P. implicatum.
Lower sheaths velvety, and nodes barbed .... 66. P. annulum.

Leaves less than 2" wide, erect, low species.
Panicle 1'—1½' long ..... 67. P. meridionale.
Panicle less than 1' long ..... 68. P. filiculme.
Stem leaves few, short, 1½' long or generally much less, distant, the densely tufted basal leaves as long as the stem leaves or nearly so, and broader; spikelets long or less.
Basal leaves ciliate around the entire margin: otherwise glabrous.
Spikelets elliptic, 1" long ..... 69. P. ciliatum.
Spikelets obovate, ¼" long ..... 70. P. polycaulon.
Basal leaves soft pubescent as well as ciliate 71. P. longipedunculatum.
Margin of basal leaves not ciliate.
Stems pubescent ..... 72. P. microphyllum.
Stems glabrous, ligule short, pubescent, ... 73. P. Brittoni.
Stems glabrous, ligule none ..... 74. P. glabrissimum.

---

1) PANICUM PORTERIANUM Nash, Torr. Bul. 22:420 (1895). *P. latifolium* Walt. Fl. Car. (1788). Not. L. (1753). *P. Walteri* Poir., (1816). Not Pursh. (1814).

Stems somewhat tufted, erect, columnar, soft-villous, or nearly glabrous, at first simple, at length somewhat branched at the top. Sheaths shorter than the internodes, or the upper ones overlapping, soft pubescent, or nearly glabrous and only the nodes barbed with soft hairs, ligule a mere margin. Primary leaves ovate-lanceolate, 2'—2½' long, ¾'—1' wide, cordate at base, abruptly acuminate, glabrous or roughish above, glabrous or soft-pubescent beneath, 6—13-nerved; secondary leaves smaller. Panicle short-peduncled, 2'—4' long, ovate, the few branches ascending or spreading; spikelets rather few, obovate, acute, nearly 2" long, pubescent.

Northern Florida and Texas to Missouri and New York.

2) PANICUM MACROCARPON Le Conte, Torr. Cat. 91 (1819). Stem strict, 12'—20' high, glabrous. Sheaths glabrous; ligule a mere margin. Leaves 2'—4' long, about 1' or more broad, 7—11-nerved, glabrous, except the rough, ciliate margins. Panicle 3'—4' long, the few-

flowered branches single, ascending; spikelets nearly 2 long, broadly obovate, obtuse.

Plant bright green. Maine and Ontario, to Minnessota, Missouri and North Carolina. Generally confused with *P. Porterianum*. This species has been supposed to be confined to Vermont, New York, Pennsylvania, and New Jersey. Maine: Fernald,, 1897· Ontario: Biltmore Herbarium, No. 7066. Missouri: Stewart Weller, 1894. North Carolina: Ashe; Mitchell Co., July, 1893. Iowa: Hitchcock, 1889.

3) PANICUM COMMELINAEFOLIUM Ashe, sp. nov. Culms tufted, erect or ascending, 8′—15′ high, stout, more or less pubescent. Sheaths more than half the length of the internodes, generally softly pubescent; ligule a mere margin. Leaves crowded, longer than the internodes, spreading or ascending, ovate-lanceolate, acuminate, abruptly narrowed to the cordate base, 11–15 -nerved, 2′—3′ long, 6″—14″ wide, glabrous above, minutely pubescent beneath, the margins ciliate and serrulate. Panicle ovate, 2′—3′ long, short-peduncled, branches numerous, spreading; spikelets smooth, elliptical, $1\frac{1}{4}$″ long, the first scale one-third the length of the 7-nerved second and third. Later forms branched above, with smaller leaves, the smaller panicles partly included in the sheaths.

A species having the foliage of *P. Porterianum*, and the spikelets of *P. commutatum*. Based on material collected by Dr. J. K. Small near Stone Mt., Ga., Aug. 1–6, 1895, and distributed as *P. commutatum*.

4) PANICUM CLANDESTINUM L. Sp. pl. 58 (1753). *P. pedunculatum* Torr. Fl. U. S. 141 (1824). Culms erect from a short rootstock, often covering many square feet, 10′—3° high; stem glabrous or nearly so above, papillosehispid below. Sheaths of primary stem one-half as long as the joints or more, the lower ones papillose-hispid, the upper glabrous, the panicle long-peduncled; sheaths on the branches much crowded and overlapping, papillose-hispid, concealing the small panicles; ligule none. Largest leaves 1′ broad, 3′—5′ long, cordate at

base, taper-pointed, glabrous except the rough margins, 9—13-nerved, those on the branches much smaller. Panicle 3′—5′ long, oval, the numerous branches spreading, many-flowered; spikelets 1¼″ long, elliptical.

Very common near the banks of streams. Related to P. scabriusculum. Torrey's P. pedunculatum represents the early form. New York: Ashe: Watkins, July, 1898. Florida: Chapman; Apalachicola. Missouri: Eggert: St. Louis, 1897. Michigan: Sartwell: Detroit, 1892. North Carolina: Ashe: Wilmington, 1894.

5) PANICUM COMMUTATUM Schultes, Mant. 2: 24 (1824). *P. nervosum* Ell. Sk. 1:122, Not Lam. *P. nervosum* Muhl. refers to another plant. Culms somewhat clustered, erect or ascending, often somewhat purplish, smooth and glabrous. Sheaths, short, glabrous except the villous margin; ligule a mere margin. Basal leaves lanceolate, or broader, glabrous; stem leaves spreading, lax, lanceolate, scarcely narrowed at the ciliate, cordate base, 2½′—3½′ long, 6″—3″ wide, glabrous on both surfaces. Panicle variable, 1′—3′ long, ovate, the branches fascicled, at length spreading; spikelets elliptical or obovate, 1¼″ long, somewhat pubescent.

Shady woods.—Very common.—Closely related to *P. Joori* and *P. Manatense*. Connecticut: Eames; Bridgeport, 1897. New York: Ashe; Ithaca, 1898. Missouri: Stewart Weller, 1894. Florida: Curtiss, 1894, No. 4636.

6) PANICUM JOORI Vasey, Contrib. U. S. Nat. Herb. III, 1:31 (1891). Culms tufted, ascending or prostrate, much branched from the base upwards, 8′—19′ long. Sheaths loose, often as long as the internodes, glabrous except the ciliate margins; ligule a mere margin. Leaves very numerous, lanceolate or broader, taper-pointed, narrowed to the cordate, sparingly ciliate base, otherwise glabrous, 7—9-nerved; later leaves much smaller. Panicle small, 1′—2′ long, nearly sessile or partly included in the upper sheath, oblong; spikelets very long pedicelled, 1¼″ long, elliptical, acute, glabrous.

Closely related to *P. commutatum*, and *P. Manatense*. Missouri,

Tennessee and southward. Missouri: Bush, July, 1895, No. 748. Tennessee: Biltmore Herbarium; Rutherford Co. No. 2984a. Louisiana: Joor. Mississippi: Tracy, 1891.

7) PANICUM MANATENSE Nash, Torr. Bul. 24 42 (1897). Stems tufted, glabrous, ascending or decumbent, soon much branched above. Lower sheaths shorter than the internodes, loose; upper crowded; ligule a mere margin. Leaves lanceolate 2'—3½' long, 5''—7'' wide, taper-pointed, cordate at the ciliate base. Primary panicle long-peduncled, 2'—3' long, broadly ovate, spikelets acute, elliptical, about 1¾'' long, first scale one-third the length of the 7—9-nerved second and third. Whole plant dark green in color.

With the foliage and general appearance of *P. commutatum* it is distinguished from it by having larger acute spikelets, and a decumbent habit. Florida: Nash; Manatee Co., 1895, No. 2428a.

8) PANICUM XANTHOPHYSUM A. Gray, Ann. Lyc. N. Y. 3: 233(1835). Culms generally single, erect, unbranched, forming no late, fascicled branches. Sheaths with a few ascending, stiff, papillose hairs; ligule a mere margin. Leaves ascending, or erect, glabrous, 4'—6' long, 5''—7'' wide, lanceolate, narrowed to the rounded base, 5—7-nerved. Panicle long-peduncled, very narrow, the few, single branches appressed; spikelets very few, short-pedicelled, 1½'' long, obovate, first scale nearly one half as long as the 7—9-nerved second and third.

Plant light green, resembling *P. calliphyllum* in color and habit. Maine to Manitoba, south to Pennsylvania. Description based on material collected by the writer in central New York, July, 1898; and the material in the Gray Herbarum; and from Maine: Merrill, 1897.

9) PANICUM CALLIPHYLLUM Ashe, sp. nov. Stems single or few together, erect, remaining entirely simple, glabrous. Sheaths shorter than the internodes, glabrous except the ciliate margin. Leaves ascending, 3'—4' long, 4''—6'' wide, lanceolate, taper-pointed, narrowed to the rounded, ciliate base, otherwise glabrous, 7—9-nerved; basal leaves few and small. Panicle sessile or short-pe-

duncled, 2'—3' long, the few-flowered branches ascending; Spikelets 1¼" to 1½" long, obovate, the slender pedicels two to many times their length.

Dry soil, central New York. Plant light green, drying yellowish. Closely resembling *P. xanthophysum* to which it is related. Type material collected by the writer at Watkins, Lake Seneca, N. Y., Aug. 1898. It has also been collected by Prof. W. W. Rowlee: East Schroeppel, N. Y., June 1895.

10) PANICUM SCABRIUSCULUM Elliott, Sk. 1:121(1817). P. Nealleyi Vasey. Culms forming large tufts, erect, 2—4 feet high, at first simple, at length much branched at each joint; stem glabrous. Lower sheaths generally spotted with purple, often papillose-hirsute or villous, the upper sheaths of the primary stem glabrous and distant; secondary sheaths papillose-hirsute and overlapping; ligule pilose; nodes sometimes barbed. Leaves ascending, linear-lanceolate, about 6" wide, 4'—7' long, the numerous branches ascending or spreading; spikelets very numerous, 1"—1¼" long, elliptical-ovate or ovate, acute, glabrous; secondary panicles concealed within the sheaths.

The affinity of this species is with *P. clandestinum*. Ditches and sunny swamps, southeastern Virginia to Texas. Not common. Virginia: Ashe; Norfolk, 1897. North Carolina: Ashe; Moore Co. 1897. Texas: Nealley, 1892.

11) PANICUM SCOPARIUM Lam. Encl. 7: 744(1797). Culms single or a few together, erect, strict, columnar, often purplish, papillose-hirsute. Sheaths papillose-pubescent, the pubescence harsh, the upper overlapping; ligule pilose. Lower leaves distant, the upper approximate, 2'—4' long, 5"—7" wide, firm, spreading, smooth above, beneath soft-pubescent. Panicle 2'—3' long, the few branches solitary, at length spreading, 1—4-flowered.

The affinity of this species is with P. Scribnerianum. Virginia: Small and Heller; Danville, June, 1892. North Carolina: Ashe; Chapel Hill, 1897. South Carolina: Ravenel; Aiken.

12) PANICUM MALACOPHYLLUM Nash, Torr. Bul. 24: 198, (1897). Stems somewhat tufted, erect, simple, at length much branched; sheaths rather loose, papillose-hirsute with spreading hairs; ligule a ring of short hairs; nodes barbed. Leaves narrowly lanceolate, acuminate, narrowed to the rounded base, soft-pubescent, the largest about 3' long, and 5" wide, 7-nerved. Panicle nearly sessile, the branches flexous, spreading, bearing a few short-pedicelled spikelets; spikelets about $1\frac{3}{4}$" long, obovate, acute, the first scale over one third as long as the very pubescent 9-nerved second and third.

Related to *P. Scribnerianum* from which it is separated by its soft pubescence, somewhat smaller spikelets, and more slender habit.—Middle Tennessee to Indian Territory.—Indian Territory: Bush; Sapulpa, May 1895. No. 1228.

13) PANICUM MALACON Nash, Torr. Bul. 24: 197 (1897). Stems very slender, tufted, erect, columnar, smoothish, 16'—24' high. Sheaths much shorter than the internodes, the lower smooth, the upper papillose-hispid with ascending hairs; ligule pilose. Leaves distant, spreading or ascending, rigid, glabrous or somewhat ciliate at the base, shorter than the internodes, oblong lanceolate, acuminate, narrowed or somewhat rounded at the base, $2\frac{1}{2}$'—4' long, 3"—4" wide, 7-nerved. Panicle sometimes much exserted, 2'—3' long, the slender, scattered, few-flowered branches erect or ascending. Pedicels two to many times the length of the spikelets; spikelets glabrous, broadly obovate, acutish, $1\frac{1}{2}$"—2" long, the first scale 1-nerved, one-third the length of the 9-nerved second and third. Later stages somewhat fasciculately branched above, the leaves a little smaller, than the primary ones and panicles barely exserted.

Dry soil Florida. Related to *P. scoparium*. Florida: Curtiss; Jacksonville, Apr. 1897. No. 5864.

14) PANICUM LIEBERGII (Vasey) Scribn. Bul. U. S.

Div. Bot. 8: 32 (1889). *P. scoparium* Lam. var. *Liebergii* Vasey, l. c. Culms single or few together, erect, 1—2 feet high, at first simple, at length much branched above, more or less pubescent with spreading hairs. Sheaths papillose-hirsute, the hairs spreading; ligule hairy. Leaves lanceolate, the largest 3'—4' long, 4"—5" wide, rounded at the base, erect, papillose-hispid beneath, above generally glabrous. Panicle narrow, about 3' long, the flexuous branches erect or ascending. Spikelets obovate 1¾" long, the first scale nearly one-half as long as the pubescent second and third.

Very closely related to *P. Scribnerianum*. Dry soil. According to Britton and Brown extending from Minnesota and South Dakota to Nebraska, Missouri and Ohio. Iowa: Pammell, 1896.

15) PANICUM SCRIBNERIANUM Nash, Torr. Bul. 22: 421 (1895). *P. scoparium* var. *minor* Scribn. (1894). Not *P. capillare* var. *minus* Muhl. *P. pauciflorum* A. Gray (1848). Not Ell. (1817). *P. scoparium* Watson Sixth Ed. Gr. Man. 632 (1889). Not Lam. Encl. 4:743 (1797). Culms 8'—20' high, tufted, erect, at first columnar, at length much branched above. Sheaths shorter than the internodes, from nearly glabrous, especially in the northern forms, to papillose-hispid, the pubescence ascending; nodes not barbed. Leaves spreading or ascending, lanceolate, 2'—3½' long, 3"—5" wide, rounded at the base, smooth above, glabrous or rough beneath. Panicle 2'—3' long, broadly oval, branches rather many-flowered; spikelets obovate, 1½" long.

Most closely related to *P. Liebergii*, and *P. scoparium*, and *P. malacophyllum*. Dry soil, North Carolina and Tennessee to Wyoming, east to Ontario and Maine. North Carolina: Ashe; Raleigh, July, 1895. Tennessee: Ruth; Knoxville; 1897. Missouri: Bush; 1894, No. 729. Wyoming: Nelson; 1894, No. 516.

16) PANICUM EQUILATERALE Scribn. Bul. 11, U. S. Div. of Agrost. 42 (1898). Stems somewhat tufted from a generally geniculate base, glabrous. Sheaths short and

glabrous; ligule a mere margin. Leaves 4'—6' long, 3"—4" wide, oblong-lanceolate, glabrous, abruptly acuminate. Panicle 2'—3' long, oval, branches spreading, rather many-flowered; spikelets elliptical to obovate, 1½" long; first scale acute, fully one-half as long as the pubescent 9-nerved second and third, fourth scale acute.

Related to *P. Ashei*, but the leaves are much longer than those of that plant, while the spikelets are as long as in *P. Porterianum*. Florida: Baldwin; Fort George. Florida: Nash; Eustis, 1894, Nos. 1220 and 1674.

17) PANICUM ASHEI, Gilbert Pearson, sp. nov. *P. commutatum* Schultes var. *minor* Vasey, Contrib. from U. S. Nat. Herb., vol. 3, No. I: 32 (1892). Not *P. capillare* var. *minus* Muhl. (1817). Culm erect, strict, single or a few together from a short root-stock, very slender, glabrous, 11'—18' high. Sheaths glabrous, the lower very short; ligule none. Stem leaves rigid, spreading, lanceolate, 1½'—3' long, 3"—4" wide, taper-pointed, scarcely narrowed at the ciliate base, glabrous on both sides, the lowest distant, the upper approximate. Panicle 2' long or less, oval, the few branches spreading; spikelets 1¼" long, elliptic, nearly glabrous. The autumnal form is sparingly branched above.

Common.—This species is closely related to *P. commutatum* from which it is separated by its slender, strict habit, more narrow, rigid and spreading leaves approximate at the top of the culm. Dry shady woods, New York to Georgia and Missouri. New York: Ashe; Ithaca, July 1898. North Carolina: Ashe; near Wilmington, June 1898. Missouri: Bush; Aug. 12, 1892, sub. nom. *P. dichotomum*, L.

18) PANICUM WEBBERIANUM Nash, Torr. Bul. 23: 149 (1896). Stems tufted, erect or ascending, 18'—24' high, smooth except below, where minutely puberulent. Sheaths smooth, except the ciliate margin, or sometimes puberulent, inflated, shorter than the internodes; ligule a mere ciliate margin. Leaves erect or ascending, lanceolate, narrowed to a rounded base, 2'—3' long, 3"—4" wide, 7—11-nerved, glabrous or the base, sparingly cili-

ate, generally purplish, very numerous. Panicle 2'—4' long, one half as wide, the slender, mostly single branches spreading; spikelets obovate, apiculate, $1\frac{1}{4}$'' long, on pedicels of about the same length or longer, first scale obtuse, about one-fourth the length of the 7-nerved second and third.

Low pine land. Florida: Nash; Lake Co., May, 1894, No. 781. Related to *P. demissum* Trin. but larger in every way and erect, whereas that is ascending from a geniculate base or is prostrate.

19) PANICUM WILCOXIANUM Vasey, Bul. U. S. Div. of Bot. 8: 32 (1889). Culms somewhat tufted, erect, about 8' high, pubescent, at least below. Sheaths shorter than the internodes, papillose-pubescent with rough, appressed or ascending hairs; ligule pilose. Leaves in the simple form not crowded, ascending, nearly lanceolate, the largest about 3' long, 2'' wide, narrowed to the somewhat rounded base, pubescent. Panicle long-peduncled, 1'—$1\frac{1}{2}$' long, ovoid, compact, the branches ascending; spikelets broadly elliptical, $1\frac{1}{4}$'' long, pubescent.

Dry, sandy soil, Nebraska. Type material collected by Dr. Wilcox in 1891. Closely related to *P. Scribnerianum*.

20) PANICUM GEORGIANUM Ashe, sp. nov. Low, 4'—8' high, densely tufted, much branched below and spreading, even before flowering; stems glabrous or soft-pubescent. Sheaths generally longer than the internodes, soft-pubescent or nearly glabrous; ligule with a few soft hairs. Leaves ascending, oblong lanceolate, 1'—2' long, about 2'' wide, taper-pointed, rounded at the base, 5—7-nerved, soft-pubescent or glabrate. Panicle short-peduncled, one inch long or less, generally overtopped by the upper leaves, the few, short branches ascending; spikelets, $1\frac{1}{4}$'' long, broadly elliptical, the first scale obtuse, one-third the length of the very pubescent second and third.

Dry sandy soil, southern Georgia and Florida. Related to *P. consanguineum*. Georgia: Small; Darden Junction, McIntosh Co., June 27, 1895. Florida: Chapman; Apalachicola.

21) PANICUM POLYANTHES Schultes, Mant. 2:257 (1824). *P. multiflorum* Ell. Sk. 1:122 (1817). Not Poir (1816). *P. microcarpon* Muhl. Gram. 111 (June 1817.) Not Muhl. ex Elliott (Jan. 1817). Culms often single, erect or nearly so, 16'—30' high, glabrous. Sheaths glabrous, generally longer than the internodes and overlapping; ligule none. Leaves ascending, scattered along the entire stem, lanceolate, 3'–6' long, 6''—10'' wide, taper-pointed, glabrous except at the ciliate, cordate base; basal leaves rosulate, ovate-lanceolate, rigid. Panicle oblong or elliptical, pointed, 3'—5' long, branches fasciculate, the lower ascending. Spikelets very numerous, nearly $\frac{3}{4}$'' long, broadly elliptical or spheroid; first scale small, one-fourth the length of the pubescent 7-nerved second and third.

Moist, shady woods, not common, Florida, Texas and Indian Territory northward to Michigan and Pennsylvania. Pennsylvania: C E. Smith, Chester. Missouri: Stewart Weller, 1892. Georgia: Ashe; Albany, 1896. District of Columbia: Holm: 1896.

22) PANICUM SPHAEROCARPON Ell. Sk.1: 125 (1817). Stems sometimes tufted, erect or ascending 12'—28' long, glabrous. Sheaths glabrous (or sometimes the lower nodes slightly barbed), the lower longer than the internodes and overlapping; ligule none. Leaves ascending, lanceolate, 2'—$2\frac{1}{2}$' long, 4''—5'' wide, long taper-pointed, ciliate at the barely rounded base, about 7-nerved. Panicle long-peduncled, oval 2'—3' long, the fascicled branches somewhat ascending; spikelets obovate or nearly spherical, $\frac{7}{8}$'' long.

Common in old fields and sunny woods, New England and Ontario to Missouri, Mexico (fide Vasey) and Florida. New York: Townsend; Niagara, 1894. Missouri: Bush; Montier, 1894, No. 763. Georgia: Small; Stone Mt. 1895. Illinois: Hill; Chicago, 1898.

23) PANICUM ERECTIFOLIUM Nash, Tor. Bul. 23: 148 (1897). *P. spaerocarpon* var. *Floridanum* Vasey, Bul. U. S. Div. of Bot. 8:33 (1889). Not *P. Floridanum*

Trin. (1834) *P. spaerocarpon* Ell. ex Chapm. Flora. First Ed. 576. Culms tufted, erect or ascending, 14'—24' high, rather stout, glabrous. Sheaths glabrous, lower generally longer than the internodes; no ligule. Leaves thick, erect, rigid, lanceolate or narrower, 2'—3' long, 4''—6'' wide, taper-pointed, rounded at the ciliate base, otherwise glabrous. Panicle 1½'—3' long, oval or oblong, branches fascicled, the lower ascending. Spikelets numerous, very small, scarcely ½'' long, spherical.

Distinguished from *P. sphaerocarpon* by having narrower, erect leaves, and smaller spikelets. Northern Florida and probably the adjacent parts of Georgia. Florida: Curtiss; Jacksonville, 1894, No. 4812.

24) PANICUM ADDISONII Nash. Torr. Bul. 25: 83 (1898). Tufted, stems erect or ascending from a geniculate base, rigid. At first simple, at length much branched, the branches erect, the lower part of the stem pubescent with long ascending hairs which become much shorter towards the top. Sheaths appressed pubescent, sometimes longer than the internodes. Leaves erect, glabrous, acuminate, lanceolate, 1'—3' long, 1½''—3'' wide; ligule pilose. Panicle, long-peduncled, ovate to oblong, the rather few branches erect or ascending; spikelets obovate, 1'' long, the first scale about one half as long as the 9—11-nerved, very pubescent second and third.

Type material from southern New Jersey. Related to *P. consanguineum*. I have found the same species in eastern North Carolina.

25) PANICUM CONSANGUINEUM Kth. Enum. Pl. 1: 106 (1833). Stems sometimes tufted, generally single, villous with soft spreading or ascending hairs, at least below, 12'—30' long, spreading or ascending from a geniculate base, at first simple, the autumnal form very much branched above, and often reclining. Sheaths shorter than the internodes, villous with soft grayish pubescence, ligule a ring of very short hairs, sometimes of longer.

Stem leaves erect, oblong-lanceolate, the largest near the middle of the stem, 2'—3½' long, 2"—4" wide, about equalling the internodes, thickish, smooth to villous; the later leaves smooth and much smaller, densely fascicled at the upper part of the stem. Panicle long-peduncled, 2'—3' long, the few long, flexuous branches ascending, few-flowered. Spikelets 1¼" long, broadly obovate, obtuse, abruptly contracted at the base, the second and third scales strongly 7—9-nerved, very pubescent.

Virginia: Ashe; June, 1897. North Carolina: Ashe; Chapel Hill, 1896. Florida: Curtiss. *P. oligosanthes* Schult. and *P. Rafinesquianum* Schult. are probably referable to this species.

26) PANICUM NEURANTHUM Griseb. Cat. Pl. Cub. 532 (1866). Culms somewhat clustered, at first simple, erect or ascending, 8'—20' long, at length very much branched above and reclining or spreading, glabrous or somewhat pubescent. Sheaths shorter than the internodes, the lower pubescent, the upper smooth, those of the fascicled secondary branches much crowded; ligule pubescent. Earlier leaves erect, flat, glabrous, linear-lanceolate, the largest 3'—4' long, 2"—2½" wide, narrowed at the base, longer than the internodes; the later crowded, smaller, linear, ascending on the spreading or reclining branches, often involute, very much longer than the small, barely exserted panicles. Primary panicle oblong, 3'—4' long, glabrous, the branches at first ascending, at length spreading, the rather few large flowers borne mostly on long flexuous pedicels; spikelets about 1" long, broadly obovate.

Dry sandy soil along the Atlantic and Gulf coasts from Virginia southward. This species is apparently very close to *P. consanguineum*. I have only been able to examine Curtiss' 3587,* which has been referred by Nash to this species, and this being in the autumnal state, is rather unsatisfactory for comparision.

27) PANICUM ANGUSTIFOLIUM Ell., Sk. 1:129(1817), *P. setaceum* Muhl. Gram. (1817). Stems generally sin-

gle, at first simple and erect, later much branched, spreading or reclining, glabrous, or below somewhat pubescent. Sheaths shorter than the internodes, the lowest generally pubescent, the upper smooth. Primary leaves erect, flat, glabrous, linear-lanceolate, the largest 3'—4' long, 2"—2½" wide, narrowed at the base, secondary leaves much smaller and crowded at the top of the ascending or reclining branches. Primary panicle oblong, 3'—4' long, glabrous, the branches at first erect, at length spreading, the flowers on long flexuous pedicels, spikelets 1" long, or over, elliptic, acute, abruptly contracted at the base.

Dry sandy soil from eastern Virginia southward to Texas. Maryland: Canby, 1894. Florida: Nash; Eustice, 1894. Mississippi: Kearney; Biloxi, 1896. Texas: Reverchon; Dallas, 1881, sub. nom. *P. neuranthum*.

28) PANICUM BICKNELLII Nash, Torr. Bul. 24:193 (1897). Culms tufted erect, slender, smooth above, puberulent below, a foot or more tall. Sheaths often longer than the internodes, the lower pubescent with the nodes bearded; ligule pubescent. Stem leaves linear-lanceolate, narrowed at the ciliate base, otherwise smooth, the largest 5'—8' long, 4"—5" wide, the upper ones longest. Panicle 2'—4' long, with ascending, flexuous branches; spikelets obtuse, oval or obovate, about 1½" long, second and third scales 9-nerved. Secondary panicles much smaller, on erect branches, and not basal as in *P. depauperatum*.

This species has the habit and appearance of *P. depauperatum*, from which it is separated by having much broader leaves and smaller spikelets. New York, Pennsylvania and New Jersey. Porter; Pennsylvania; Chambersburg, July, 1896.

29) PANICUM DEPAUPERATUM Muhl. Gram. 112 (1817). *P. strictum* Pursh Fl. (1814). Not R. Br. (1812). *P. rectum* R. & S. *P. involutum* Torr. Stems tufted, 8'-18' high erect, mostly glabrous. Upper sheaths elon-

gated, glabrous or hirsute; ligule hairy. Stem leaves erect, longest towards top of culm, 3' to 8' long, 1½"—2" wide, smooth or hirsute, sometimes involute; basal leaves similar to those of the stem but shorter. Panicle loose, 3'—5' long, branches erect or ascending, mostly single, flexuous, few-flowered, pedicels mostly very long; spikelets 1½"—2½" long, broadly elliptical or obovate, acute, the 8-nerved second and third scales much longer than the obtuse fourth.

Elliott does not seem to have known this species. Throughout the eastern United States from Maine and Florida to Texas.

Dry, sandy woods and fields. Washington, D. C.: Holm, 1895. Iowa: Bessey; Ames, 1872. Georgia: Ashe; Stone Mountain, 1896 Texas: Reverchon. New Hampshire: Eaton; Seabrook, 1898.

30) PANICUM LINEARIFOLIUM Scribn. Bul. 11, U. S. Div. of Agrost. 42 (1898). Densely tufted, 8'—14' high, stems erect, smooth. Sheaths somewhat shorter than the internodes, usually hirsute; ligule hairy. Leaves linear-lanceolate, erect, firm, 2'—6' long, 1½"—2" wide, the base barely narrowed, glabrous above, or with a few long hairs, below appressed pubescent. Primary panicle open, 2'—4' long, the mostly single branches ascending, the rather few spikelets borne on pedicels two to many times their length. Spikelets elliptical, obtuse, 1" or slightly more long, very strongly 7-nerved. Secondary panicles crowded at base of the culms.

Maine and New Jersey to Minnesota and Missouri. Distinguished from *P. depauperatum* by having more slender, obtuse spikelets; while its somewhat longer, more elliptical spikelets, its pubescence and the basal panicles separate it from *P. Werneri*. Minnnesota; Holzinger; June, 1888. Maine; Merrill: July, 1898. Illinois; Hall; 1862. Missouri: Bush, 1892.

31) PANICUM WERNERI Scribn. Brit. and Brown's Ill. Flo. 3; 501(1898). Densely tufted, stems very slender, smooth and glabrous throughout. Sheaths smooth, ligule a mere margin. Leaves linear, erect, often overtopping the panicles, the upper leaves the longest, 3'—7'

long, 1''—2'' wide, glabrous. Panicles long-peduncled, 2'—4' long, loose, the slender flexuous, generally solitary branches ascending ; spikelets about 1'' long, obovate, the first scale about one third the length of the 7-nerved second and third. Secondary basal panicles only sparingly developed.

Very close to *P. linearifolium*. Connecticut to Ohio in swamps. Connecticut: Eames; Fairfield, 1896. New York; Rowlee; Ithaca, 1892.

32) PANICUM NEMOPANTHUM Ashe, sp. nov. Tufted, stems erect, 14'—20' high, glabrous. Sheaths glabrous, or the lowest pubescent, the upper sometimes longer than internodes, the nodes, at least the lower ones, barbed with long hairs ; ligule none. Leaves linear lanceolate, spreading or ascending, long taper-pointed, glabrous or ciliate toward the narrowed base. Panicle 3'—4' long, broader than long, the mostly single branches wide-spreading, lax and drooping, few-flowered ; spikelets elliptic, acute, nearly 1½'' long, on long, flexuous pedicels, the obtuse first scale over one-third the length of the glabrous, 7-nerved second and third.

Type material collected by the writer April, 1895, in the Penitentiary woods, Raleigh, N. C. A very distinct species.

33) PANICUM DICHOTOMUM L. Sp. Pl. 58 (1753). *P. ramulosum* Mx. *P. nodiflorum* Lam.? Several stems together, 10' -- 24' high, erect. Sheaths, except the lowest, glabrous, lowest node occasionally barbed and its sheath pubescent. Sheaths shorter than the internodes; ligule none. Leaves spreading, lax, largest 1½'—2½' long, 3''—4'' wide, narrowed to a rounded, sparingly ciliate base, otherwise glabrous. Primary panicle 2' or more long, oval, the branches lax; spikelets 1'' long, elliptic, glabrous.

Shady woods throughout the eastern United States north of Florida and Texas. Florida: Chapman; Apalachicola. Texas: Nealley; Rock

land, 1892. New York: Rowlee; Ithaca, 1895. Maine: Fernald; 1895. This is the most common vernal species from North Carolina northward. Elliott seems to have overlooked this species. His P. dichotomum is either *P. demissum* or *P. arenicolum* or some closely related species, which, in habit, resembles *P. angustifolium*, as he compares his *P. dichotomum* with *P. angustifolium* in both habit and form.

PANICUM DICHOTOMUM ELATUM Vasey Contrib. from. U. S. Nat. Herb. vol. 3 No. 1: 30 (1892). Stems stouter, leaves longer, 2½'—3' long, panicle very much larger than in the type, 3'—4' long and fully as wide. Maryland and southward. District of Columbia: Scribner 1894. North Carolina: Ashe; Chapel Hill, 1897.

PANICUM DICHOTOMUM VIRIDE Vasey, Contrib. from U. S. Nat. Heb. Vol. 3, No. 1: 30 (1892) is a tender, slender, few flowered form, growing in very deep shady woods. It is very common to the northward, but is less common to the south. It does not branch or only sparingly during the summer, the basal nodes and sheaths are glabrous, and it is probably specific. It approaches *P. lucidum*.

P. dichotomum has been burdened with numberless varieties by later American authors, most of these varieties being well-marked species, which were so regarded by early American botanists.

34) PANICUM BOREALE Nash, Torr. Bul. 22: 421 (1895). Culms generally tufted, ascending or erect, 14'—20' high, glabrous. Sheaths glabrous, except for the ciliate margin, often as long as the internodes; ligule of very short hairs. Leaves glabrous, lanceolate, or sometimes ciliate at the base, 3'—5' long ½' wide or less, taper-pointed, narrowed to the rounded base, ascending. Panicle 2'—3' long, nearly as broad, branches numerous, fascicled, very slender; spikelets 1" long, elliptic, acutish, nearly glabrous, rather numerous, on long filiform ascending or spreading pedicels. Autumnal form unbranched.

Northern New England to Minnesota, South to Pennsylvania. Related to *P. dichotomum*. Maine: Merrill; East Cerbum. New York: Ashe; Courtland, 1898.

35) PANICUM MACULATUM Ashe, sp. nov. Culms single, erect, glabrous, at length sparingly branched. Sheaths shorter than internodes, glabrous, spotted; ligule none. Basal leaves and nodes glabrous; stem leaves ascending, largest 3'—4' long, 4''—5'' wide, lanceolate, tapering to the rounded glabrous base, margins very rough, 5—7-nerved. Panicle 2'—3' long, nearly as broad, oval, the clustered branches lax. Spikelets $\frac{7}{8}$'' long, obovate, acute.

Related to *P. dichotomum*, from which distinguished by the longer, ascending leaves and smaller spikelets, Spikelets about the size of those of *P. barbulatum*. Collected by the writer at Raleigh, N. C. May, 1895.

36) PANICUM ROANOKENSE Ashe, sp. nov. Culms somewhat tufted, 18' or more high from a geniculate base. Plant glabrous throughout. Sheaths one-half as long as the internodes or more; ligule none. Leaves glabrous, ascending, narrowly lanceolate, 2'—3' long, 2''—3'' wide, firm, 5—7-nerved. Panicle $2\frac{1}{2}$'—$3\frac{1}{2}$' long, broadly oval, the slender, fascicled branches spreading or drooping; spikelets numerous, 1'' long, elliptical-obovate, glabrous.

Type material collected by writer in dry soil, Roanoke Island, N. C. June, 1898; also collected at Rose Bay and Mackleyville, N. C., the same month.

37) PANICUM DEMISSUM Trin. Sp. Gram. 3: 319 (1836), *Panicum Nashianum* Scrib. Bul. U. S. Div. of Agrost. 7: 79 (1897). Stems tufted, 10'—18' long, very slender, wiry, rising or reclining from geniculate base, joints geniculate, purplish, glabrous or minutely rough, puberulent below, at first simple, becoming much branched above late in the season. Sheaths much shorter than the internodes, the upper ones glabrous, the lower gen-

erally puberulent; ligule none. Leaves ascending, oblong-lanceolate, 1½' long or less, about 2" wide, 1' longest and broadest near the base of the culm, the upper reduced in size, glabrous. Panicle short-peduncled or sessile, 1'—2' long, the branches short, flexuous, spreading; spikelets obovate, 1" long, contracted at the base, glabrous.

Related to *P. Webberianum*, but distinguished by being much smaller and ascending from a geniculate base. Common in the pine barrens. North Carolina; Ashe; near Newberne, 1898. Georgia; Small; near Thomasville, June, 1892. Florida; Curtiss; Jacksonville, No. 4637, 1894.

38) PANICUM MATTAMUSKETENSE Ashe, sp. nov. Erect, sometimes tufted, strict, rather stout, 2 feet to 4 feet high, often purplish, nodes strongly barbed. Lower leaves and sheaths soft-pubescent the upper glabrous; ligule pubescent, otherwise glabrous. Leaves lanceolate. 3'—5' long, 4"—7" wide, spreading. Panicle 3'—5' long, ovoid, long-peduncled, the branches numerous, clustered; spikelets ellipsoid, glabrous, pointed, 1" long, first scale one-third the length of the spikelet.

Roadsides, ditch banks and wet open woods around lake Mattamuskeet, N. C., where it grows with *P. barbulatum*. June and July. The later stages profusely branched above with shorter leaves and small few-flowered panicles. Collected by the writer, and Mr. Gilbert Pearson in June, 1898.

39) PANICUM BARBULATUM Mx. Flora, 1:49(1803). *P. discolor* Spreng, ex Muhl. Gram. 114(1818). *P. heterophyllum* Schreb? Stems erect, often tufted, 2 feet to 3 feet high, the nodes barbed, otherwise glabrous. Sheaths shorter than the internodes, glabrous; ligule pubescent. Leaves spreading or ascending, lanceolate, rounded at the base, 3'—4' long, 3"—6" wide. Panicle 3'—5' long, ovoid, peduncled, the branches fascicled, numerous; spikelets ellipsoid about ¾" or less long, pointed. The later stage very much branched above, with smaller leaves and small, few-flowered panicles.

Wet shady places, very common. Florida and Texas to (according to Britton & Brown) Ohio and Connecticut. Texas: Nealley; No. 26. Florida: Chapman; Apalachicola, Biltmore Herbarium, No. 803c. District of Columbia: Kearney, 1895. Kentucky: Miss Price; Bowling Green. This species has the general appearance of *P. dichotomum*, but is distinguished by the smaller spikelets and barbed nodes. Nearly related to *P. annulum* and *P. Matlamusketense*.

40) PANICUM ENSIFOLIUM Baldwin, Ell. Sk. 1:526 (1817). *P. albo-marginatum* Nash, Torr. Bul. 24:40 (1897). Stems tufted, branching from the base or near it, glabrous, 8'—14' high. Sheaths generally much shorter than the internodes, crowded on the branches above, glabrous, except the very short, hairy ligule. Leaves glabrous, lanceolate, mostly clustered near the base of the stem, the largest 1½'—2' long, 3"—4" wide, the margins white and thickened, upper reduced in size. Panicles small, 1'—1½' long, long-exserted, oval, the branches ascending; spikelets numerous, ¾" long, elliptical-obovate, the first scale about one-fourth as long as the pubescent 7-nerved second and third.

Moist or dry woods middle North Carolina to Florida. North Carolina: Ashe; Chapel Hill, June, 1896. Georgia: Baldwin. Florida: Nash; Lake county, 1894, No. 925. A specimen in the herbarium of the Philadelphia Academy of Science sent by Baldwin from Georgia, and labelled by him *P. ensifolium*, matches my material from North Carolina and Nash's from Florida. It also agrees very well with Elliott's description of this species.

41) PANICUM BALDWINII Nutt. ex Chapman, Flora, 3rd edition 586 (1896). Densely cespitose, glabrous, stems much branched near the base, low 8'—16' high, stiff and rigid. Sheaths smooth; ligule pubescent. Stem leaves rigid, erect, narrowed at base, ½'—1½' long, acuminate, glabrous. Basal leaves tufted. Panicle 1' or less long, much divided; the obovate or elliptic spikelets barely ½" long, the second and third scales indistinctly 5-nerved.

Georgia: Baldwin, in Herb. Philadelphia Acad. of Natural Science. Florida: Curtiss; Indian river, No. 5804. Florida: Chapman; Apalachicola. Related to the next.

42) PANICUM WRIGHTIANUM Scribn., Bul. 11, U. S. Div. of Agrost., 44 (1898). Stems densely tufted, much branched above, sometimes puberulent. Sheaths very short, occasionally pubescent; ligule sometimes pubescent. Leaves lanceolate, somewhat rounded at the base, 1'—2' long, erect, glabrous, taper-pointed. Panicle oblong, ½'—1½' long, branches fascicled, short; spikelets obovate, less than ½" long, second and third scales faintly 5-nerved.

Florida and westward along the South Atlantic and Gulf coasts. Florida: Nash; Lake county, 1894, No. 1238. Florida: Curtiss; Jacksonville, 1894, No. 5588. North Carolina: Ashe; near Newberne, 1898.

43) PANICUM SPHAGNICOLUM Nash, Torr. Bul. 22: 422 (1895), Cespitose, stems at first erect, soon reclining and much elongated, 12'—30' long, very slender, glabrous. Sheaths much shorter than the internodes, glabrous, no ligule. Leaves erect, ½'—1½' long, 2"—3' wide, narrowly lanceolate, narrowed to the somewhat rounded base, glabrous, 5-nerved. Panicles 1'—1½' long, branches erect, or ascending; spikelets ¾" long, broadly obovate, glabrous, the second and third scales 7-nerved.

Delaware to Florida and Tennessee. At first unbranched, eventually with slender, reclining branches and small, sessile panicles. Color light green. Delaware: Canby; Ogleton, June, 1896. District of Columbia: Kearney; June, 1897. North Carolina: Small; Duns' Mt., August, 1894. North Carolina; Biltmore Herbarium, Biltmore, August, 1898 No. 5066b. Florida; Nash, No. 2500.

44) PANICUM LUCIDUM Ashe, sp. nov. Cespitose, culms reclining or prostrate, weak, glabrous. Sheaths glabrous, except the ciliate margin, very short; ligule none. Leaves spreading, 1' long or generally less, narrowly lanceolate, very acute, narrowed to the base, glabrous, rather distant. Panicle peduncled, 1½' long or less, equally as wide, the branches single or several together,

wide-spreading; spikelets about $\frac{7}{2}$'' long, elliptic or narrowly obovate, acute, glabrous.

Collected in June 1898 by the writer in deep, shady swamps bordering lake Mattamuskeet, N. C. Probably found in other swamps along the coast of the southern states. Very different from *P. sphagnicolum*.

45 PANICUM CUTHBERTII Ashe, sp. nov. Culms very slender, erect or spreading, densely tufted, glabrous, 8'—24' long, the autumnal state unbranched or slightly so. Sheaths very short, glabrous; no ligule. Stem leaves distant, narrowly lanceolate, taper-pointed, 3 to 5 nerved, narrowed at the base, thin, glabrous, $\frac{1}{2}$'—$1\frac{1}{2}$' long, 1''—2'' wide, spreading or ascending; basal leaves densely tufted. Panicle broadly oval about 1' long, the slender branches spreading; spikelets narrowly elliptical, acute, $\frac{1}{2}$'' long, the first scale one-fourth the length of the 7-nerved finely pubescent second and third.

Wet sandy woods, North Carolina and South Carolina. South Carolina: Cuthbert; St. Helena island. North Carolina: Ashe; Chapel Hill, June, 1898. It is separated from *P. ensifolium* by the strict habit and arge basal leaves of the latter; while *P. sphagnicolum* has the branches of its panicle ascending and larger obovate spikelets; and *P. lucidum* has much larger and broader spikelets, and a decumbent habit.

46) PANICUM PARVISPICULATUM Nash, Torr. Bul. 24:347 (1897.) *P. microcarpon* (?) Muhl. ex Ell. Sk. 1:127 (1817). Stems tufted, erect, 8'—30' high, glabrous, or with some appressed pubescence on the lower part and sometimes with the nodes barbed. Sheaths very short, generally glabrous, the lower sometimes pubescent; ligule short, pilose. Leaves distant, ascending, much shorter than the internodes, lanceolate, narrowed at the base, 2'—3' long, 3''—4'' wide, generally glabrous. Basal leaves oblong lanceolate, 2'—4' long, about 4'' wide, stiff and erect. Panicle $1\frac{1}{2}$'—3' long, oval or oblong, the numerous ascending branches thickly fascicled; spikelets very numerous, small, scarcely $\frac{1}{2}$'' long, broadly oval.

This species is intermediate between *P. leucothrix* Nash. and *P. niti-*

dum Lam., and is the *P. nitidum* of Dr. Chapman's Southern Flora. It is also probably the *P. microcarpon* of Elliott. It occurs along the coast as far north as eastern Virginia. As it is variable in the amount of pubescence, some specimens being quite glabrous, and others having the stems and sheaths pubescent, and nodes barbed, it is possible that Elliott may have based his *P. microcarpon* on specimens of the pubescent form. Virginia: Curtiss; Bedford Co., 1873, sub nom. *P. nodiflorum* Lam. North Carolina: Ashe; Wilmington, 1895. Florida: Chapman; Apalachicola. Curtiss, Jacksonville, No. 4033.

47) PANICUM LEUCOTHRIX Nash, Torr. Bul. 24:41 (1817). Stems somewhat tufted, slender, 12'—30' tall, glabrous, or pubescent below. Sheaths shorter than the internodes, glabrous or the lower pubescent; ligule pilose. Leaves lanceolate, 1½' long or less, 1"—2" wide, narrowed to the base, spreading or ascending. Panicle oblong, ¾'—1½' long, the numerous short fascicled branches ascending; spikelets very numerous, less than ½" long, spheroid, whitish or purple.

Central Florida to North Carolina near the coast. Florida: Curtiss; Jacksonville, 5912. North Carolina: Ashe; Manteo, June, 1898. Reated to *P. parvispiculatum*. This is Elliott's *P. nitidum*.

48) PANICUM EATONII Nash, Torr. Bul. 25: 84 (1898). Erect, 1'—3' tall, glabrous. Sheaths smooth: ligule pilose. Leaves lanceolate, taper-pointed, ascending, becoming much smaller towards top of culm, the largest 3'—4' long, and 4"—5" wide: panicle long-peduncled, oblong, 3'—5' long, the numerous short branches ascending; spikelets oval, about ¾" long, first scale about one-third as long as the pubescent, 7-nerved second and third.

"Wet places along the coast, Maine to New York." Description based on material sent me by Mr. A. A. Eaton of Seabrook, N. H.

49) PANICUM COLUBIANUM Scribn. Bul. U. S. Div. of Agrost. 7: 78 (1897). Stems somewhat tufted, 8'–20' high, strict, glabrous or the lower pubescent: ligule pilose. Leaves distant, ascending, lanceolate, taper-pointed, the upper reduced in size, largest 2'—3' long,

3"—4" wide. Panicle long-peduncled, mostly smooth, 1'—2' long, at first contracted, later pyramidal, branches numerous, fascicled; spikelets broadly ovate, $\frac{3}{4}$" long purplish, first scale minute, second and third 7-nerved, pubescent. Later stages fasciculate branched, the small branches and leaves ascending.

Too close to *P. nitidum*, from which it is distinguished only by its smaller size, and smaller panicle. New Jersey: Commons; 1897. District of Columbia: Kearney; June, 1897.

50) PANICUM NITIDUM Lam. Encl. 4; 748 (1797). Stems often tufted, erect, strict, 10' to $3\frac{1}{2}$ feet high, nearly glabrous; later stages much branched from the sheaths. Sheaths shorter than the internodes, glabrous or with soft ascending hairs, or, to the southward, the lower sheaths papillose-hirsute; ligule pilose. Leaves firm, ascending, 7—9-nerved, oblong-lanceolate, 2'—4' long, 3"—4" wide, glabrous, or appressed pubescent beneath, shorter than the internodes; upper much reduced. Panicle 2'—3' long, broadly oval, at least the lower branches ascending, spikelets numerous, on very slender pedicels, about $\frac{3}{4}$" long, broadly ovate.

New England to North Carolina, and Wisconsin. Its distribution farther westward undetermined.

District of Columbia: Kearney; 1897. North Carolina: Ashe; 1898. Wisconsin: Pammel; Prairie du Chien, 1891.

This is a very confusing and variable species. I have studied it in the field for three seasons and have carefully noted its variability. To the northeast, where it is common at least as far as New Jersey, it is generally glabrous or nearly so; to the southward it is often pubescent, with the sheaths papillose-hirsute, though the glabrous form occurs occasionally along with it. It is variable in size and in the shape and size of its spikelets, even on the same individual. The long pilose ligule, however, is constant. To the extreme southeast *P. leucothrix* occurs, which is closely allied to *P. nitidum*, and is the *P. nitidum* of Elliott. It is also very variable in its pubescence and in the size and shape of its spikelets. In the extreme west *P. nitidum* is represented by *P. thermile* Boland, a rather low, nearly glabrous species; while closely allied to it is a very villous form with larger, narrower spikelets, which seems to be specific. Its description follows:

51) PANICUM HUACHUCAE Ashe, sp. nov. Stems somewhat clustered, erect, slender, villous, 2 feet to 3 feet high. Sheaths shorter than the internodes, villous to papilose-hirsute; ligule long-pilose. Leaves erect or ascending, 3'—4' long, 3"—4" wide, generally villous, oblong-lanceolate. Panicle 3'—5' long, oval, pubescent; spikelets nearly 1" long, oval, or elliptical, pubescent.

Based on: Lemnon: *P. dichotomum* var. *nitidum*, subvar. *barbulatum*; Huachuca Mountains, Arizona, 1882. North Carolina: Ashe; Chapel Hill, June, 1898. Iowa: Bessey; Ames, 1875. Delaware: Commons; sub nom., *P. lanuginosum*. Missouri: Glatfeller; St. Louis, 1897.

52) PANICUM VISCIDUM Ell. Sk. 1: 124 (1817). *P. scoparium* Mx. Flora 1: 49(1803). Not Lam. (1797). Tufted, large and stout, 2 feet to 3 feet high, ascending, from a generally geniculate base; stem pilose, especially below. Sheaths shorter than the internodes, pilose on the lower part, the upper generally viscid, barbed at the nodes, with a naked viscid ring below the node; ligule of very short pubescence. Leaves 3'—5' long, 4"—7" wide, lanceolate or narrower, narrowed to the base, glabrous above, generally pilose beneath. Panicle short-peduncled, 2'—4' long, broadly oval, the numerous, fascicled branches ascending; spikelets broadly obovate or nearly spherical, $1\frac{1}{8}$" long, apiculate; axis of panicle often viscid. Later state much branched.

New Jersey to Florida and Texas. Frequent in wet or moist sandy places. Florida: Chapman, Apalachicola. Delaware: Canby, 1894. Texas: Reverchon. North Carolina: Ashe, 1897.

53) PANICUM CILIIFERUM Nash, Torr. Bul. 24: 195 (1897). Culms tufted, erect or ascending from a geniculate base, the joints geniculate. 18' — 24' high. more or less villous below with appressed or ascending hairs, above smooth. Sheaths much shorter than the internodes, villous with soft, appressed pubescence; pubescence of ligule very short or sometimes long and villous.

Stem leaves erect or ascending, long-acuminate, broadest near the somewhat rounded base, the lowest lanceolate, 2'—4' long, 4"—5" wide, 9—13-nerved, the upper much reduced. Panicle pyramidal, 2'—4' long, the fascicled branches very long and slender, spreading or the lowest reflexed, spikelets purple, obovate, abruptly contracted at the base, 1" long, the first scale one-third the length of the smooth, 9-nerved second and third.

Shady pine lands, Eastern North Carolina to Florida. North Carolina: Ashe, Manteo, 1898. Florida: Curtiss; Jacksonville, 1897, No. 5866. Related to *P. arenicolum* but larger in every way, more pubescent, and with longer leaves.

54) PANICUM TSUGETORUM Nash, Torr. Bul. 25: 86 (1898). Stems tufted, 18' or less high, at first erect, and simple, at length much branched above and prostrate, pubescent with short ascending hairs, or with longer ones towards the base. Sheaths shorter than the internodes, pubescent with ascending hairs; ligule short, pubescent. Leaves lanceolate, the largest 2'—3' long, 3"—4" wide, later ones smaller, glabrous above, beneath appressed pubescent. Panicle broadly oval, about 2' long, the branches ascending; spikelets broadly obovate, about $\frac{7}{8}$" long, pubescent.

Hemlock woods; Connecticut, and New York.

55) PANICUM TENNESSEENSE Ashe, sp. nov. Tufted, low, 5'—12' high, erect or ascending from a geniculate base, very slender, at first simple, soon densely branched above with short branches, glabrous or nearly so. Sheaths often nearly as long as the internodes, at least the lower ones covered with a short, soft pubescence; ligule short-pilose. Leaves spreading, thin, 3—5-nerved, the margins very rough, smooth above, beneath appressed pubescent and roughish, the largest $2\frac{1}{2}$'—3' long, 3"—4" wide, widest in the middle, abruptly pointed, narrowed to the rounded base; secondary leaves thickly

crowded above, about 1' long, spreading, much longer than the very numerous, short, secondary panicles. Primary panicles short-peduncled, 1'—2' in length, oval, the spreading branches mostly single, rather few flowered, the slender peduncles two to many times the length of the obovate, pubescent, $\frac{3}{4}$" long spikelets.

Related to *P. Joorii*, which it somewhat resembles. Based on No. 7087 Biltmore Herbarium: Cedar glades, LaVergne Co., Tennessee.

56) PANICUM ATLANTICUM Nash, Torr. Bul. 24:346 (1897). Culms tufted, erect or ascending from a usually geniculate base, 10'—20' high. Stem more or less pilose with spreading or ascending hairs, the nodes long-barbed above the naked ring. Sheaths pilose to villous, generally papillate, the lowest nearly as long as the internodes, the upper much shorter; ligule pilose, hairs 2"—3" long. Stem leaves ascending, above smoothish, below generally villous, the margins often ciliate with long hairs, 2'—3' long, 2"—3" wide, linear-lanceolate; narrowed at the somewhat rounded base, taper-pointed, middle leaves the longest; basal leaves much shorter; the later leaves on the secondary branches, ascending, one-half the length of the primary, smooth. Panicle 2'—3' long, nearly as wide, long-peduncled, the branches somewhat ascending, spikelets rather numerous, obovate, acute, quite 1" long, the first scale full one-third as long as the minutely pubescent 9-nerved second and third; later panicles not expanding, one-half the length of the surrounding leaves.

New York to North Carolina, and probably farther southward, generally near the coast. Delaware: Commons; 1872. North Carolina: Ashe; Cape Hatteras, 1898.

57) PANICUM SCOPARIOIDE Ashe. sp. nov. Stems single or a few together, erect, columnar, 16'—20' high, appressed pubescent. Sheaths papillose-pubescent, with ascending or appressed hairs, the lower much shorter than the internodes, the upper longer; ligule pilose.

Leaves linear-lanceolate, spreading and ascending, 2'—3' long, about 3" wide, rounded at the base, generally 9-nerved, beneath appressed pubescent, above glabrous, lower leaves distant, the upper approximate. Panicle 1½'—2' long, broadly oval, the branches fascicled, spreading, spikelets rather numerous, broadly obovate, somewhat over 1" long, apiculate, the acute first scale scarcely one-third the length of the nearly smooth 7-nerved second and third.

A species with the habit of *P. scoparium*, and spikelets which are nearly the size and shape of those of *P. viscidum*. Based on No. 283, ex Herb. A. Commons. Dry soil, Centreville, Del. June, 1873. Distributed sub nom. *P. Scribnerianum* Nash.

58) PANICUM VILLOSSISSIMUM Nash, Torr. Bul. 23: 149 (1896). Stems erect or ascending, tufted, slender, 16'—24' high, villous with long, ascending hairs, barbed above the glabrous nodes, joints geniculate. Sheaths much shorter than the internodes, villous; ligule pilose. Stem leaves linear-lanceolate 2½'—4' long, 3"—4" wide, rounded at the base, ascending, longest about the middle of the culm, the upper scarcely reduced, more or less villous with spreading hairs; basal leaves much shorter and not conspicuous. Panicle 2½'—3½' long, equally as broad, the numerous slender branches fascicled; spikelets obovate, about 1" long on slender pedicels.

Collected by Dr. J. K. Small in the Ocmulgee river swamp in May, 1895. Related to *P. pubescens* and *P. haemacarpon*.

59) PANICUM PUBESCENS Lam. Encl. 4:748 (1797). Culms tufted' 10'—20' high, slender, erect, joints geniculate, stem to base of panicle villous with long, white, spreading hairs, a ring of longer hairs above the joint, below which is a naked ring. Sheaths about one half the length of the internodes, villous with long white hairs, minutely papillate; ligule pilose. Stem leaves ascending, linear-lanceolate, gradually narrowed at the base, taper-

pointed, villous to sparingly hirsute, 7--9-nerved, the longest about 3' long and 3" wide; upper leaves much reduced in size; basal leaves hirsute, shorter and broader. Panicle about 2 inches long, nearly as broad, the branches single or in pairs, spreading or ascending; spikelets somewhat obovate, obtuse, scarcely 1" long, first scale one third the length of the pubescent, 7-nerved second and third; peduncled 2 to 3 times the length of panicle. The late form densely fasciculately branched and spreading.

Maine to Iowa, Georgia and Missouri. Very close to *P. implicatum*. Maine: Merrill, 1895. Georgia: Ashe; Atlanta, 1896. Iowa: Cratty; Armstrong, 1889, No. 1067. Missouri: von Schrenk; St. Louis, 1897.

60) PANICUM COMMONSIANUM Ashe, sp. nov. Stems clustered, erect, strict, 8'—16' high, below appressed pubescent, above glabrous or puberulent. Sheaths shorter than the leaves or the lower overlapping, the lower appressed pubescent with ascending hairs, the nodes densely barbed with short ascending hairs. Leaves glabrous, or sparingly ciliate near the base erect or ascending, narrowly lanceolate, gradually narrowed to the apex from near the base; 1½'—2' long, ligule pilose. Panicle 1½' —3' long, as broad as long, the branches fascicled, spreading, long-peduncled, glabrous or the axis puberulent; spikelets 1" long, obovate, or broadly elliptical, pubescent. Roots very long and fibrous.

Based on No. 341, Commons. Collected in drifting sands along the coast, Cape May, N. J. June, 1898. Related to *P. haemacarpon*.

61) PANICUM HAEMACARPON Ashe, sp. nov. Tufted, stems erect or ascending from a geniculate base, 12'—18' high, below villous with long spreading or ascending hairs, above sometimes smoothish. Sheaths shorter than the internodes, papillate, villose with long soft, spreading hairs; the nodes bearded with spreading or reflexed hairs.

Leaves erect or ascending, 1'—2' long, 2''—3'' wide, lanceolate, the middle ones longest, the upper much reduced, the lower pilose beneath, the upper pubescent with long scattered hairs on the upper surface, appressed pubescent, often papillate, beneath. Panicles $1\frac{1}{2}$'—2' long, broader than long, the branches wide-spreading somewhat fascicled, rather few-flowered; spikelets 1'' long, broadly obovate, apiculate, the first scale one-third the length of the pubescent second and third. Spikelets generally red, or purplish.

Closely related to *P. villosissimum* from which separated by its generally ascending habit, erect leaves, the upper reduced, and shorter usually ascending pubescence. District of Columbia: Kearney; 1897. Ashe: North Carolina; Chapel Hill, 1898. Iowa: Carver; Jewell Junction, 1895, No 258.

62) PANICUM ARENICOLUM Ashe, sp. nov. Erect from a usually geniculate base, 10' to 24' high, pubescent, at least below, with soft ascending hairs. Sheaths shorter than the joints, pubescent with short ascending hairs Stem leaves erect or ascending, longest near the base of the stem, much reduced in size upward, the largest 2'—3' long, 2'' wide, long taper-pointed, glabrous above, beneath more or less papillose-pubescent. Panicle long excerted, 2'—3' long pyramidal, the flexuous fascicled branches spreading, at length reflexed. Spikelets somewhat less than 1'' long, obovate, obtuse.

Intermediate in size, habit, and general characters between *P. ciliiferum and P. demissum*, smaller than the former and larger than the latter. Type material collected by the writer at Chapel Hill, N. C. June 1898, and later at several localities in the eastern portion of the same state.

63) PANICUM LAXIFLORUM Lam. Encycl. 4: 748 (1797). *P. Muhlenbergii* Nutt. in Herb. *P. acuminatum* Swarz. ex Muhl. Gram. Stems densely tufted, ascending or spreading or later reclining, 15'—20' long, smooth or somewhat pubescent. Sheaths very short,

one-third the length of the leaves, papillose-hirsute: ligule a mere margin. Stem leaves few, mostly near the base of the culms, ascending or spreading, narrowly lanceolate, very taper-pointed, narrowed at the base or somewhat rounded, 7 to 9-nerved, the largest 3'—4' long, 4"—5" wide, the upper leaves, scarcely reduced in size, glabrous or hirsute with long white hairs, often with ciliate margins; basal leaves shorter but similar to those of the stem, ciliate-margined, often hirsute, very abundant, soft and lax. Panicle 3' to 4' long, obovate, the branches slender, lax; spikelets obovate, about 1" long, the acutish first scale one-fourth the length of the very pubescent, 9-nerved second and third.

Late panicles included in very short sheaths which are not longer than the basal leaves. Primary culms do not become fasciculately branched. Color light green. Damp shady hillsides, Maryland and Kentucky to Alabama and Florida. The basal leaves form large tufts which remain green throughout the winter. It is one of the earliest spring species. April-July. West Virginia; Small, 1892. Florida; Curtiss, Juniper, 1895, No. 5537. Tennessee; Ruth, 1897. *Panicum caricifolium* Scribn. in herb. as distributed by Kearney (Washington, D. C., May, 1897) differs from this only in its somewhat smaller—quite ¾" long spikelets.

64) PANICUM LANUGINOSUM Elliott. Sk. 1:123 (1817). Stems ascending from a geniculate base, rather stout, 12'—24' long, villous below, pubescent above. Sheaths shorter than the leaves, the lower, at least, densely pilose with soft pubescence, the upper often glabrous, barbed above the naked joint; ligule a ring of long hairs. Stem leaves lanceolate, rounded at the base, spreading or ascending, the largest near the base of the stem, 2½'—3' long, 3"—4" wide, 9—11-nerved, generally soft-pubescent beneath, glabrous above, or the lowest pilose on both sides, finely ciliate on the margins, particularly the upper ones toward the base; upper leaves much reduced in size. Panicle 2'—3' long nearly as wide, the numerous, fascicled, smooth branches ascending; spikelets small for size of

plant, about $\frac{3}{4}$'' long, obovate, very pubescent, first scale about one-third as long as the 7-nerved second and third. Peduncle twice the length of panicle.

Dry sandy fields, New Jersey to Georgia near the coast. Related to *P. viscidum*. Description based on plants growing at Chapel Hill, N. C. Delaware: Commons; Mt. Cuba, 1871. Washington, D. C.: Kearney; 1897 Ashe; North Carolina: Chapel Hill, 1898.

65) PANICUM IMPLICATUM Scribn. Bul. 11, U. S. Div. of Agrost. 43 (1898). Culms erect, tufted, 12'—20' high, very slender, somewhat geniculate at the nodes. Stem, to base of panicle, more or less pubescent with short white hairs, barbed above the naked ring at the joints. Sheaths about one-half the length of the internodes, more or less hirsute, at least below; ligule a ring of hairs 2'' long. Stem leaves ascending, linear-lanceolate, gradually narrowed to the base, 2'—3' long, about 3'' wide. 7—9-nerved, more or less pubescent; basal leaves much shorter, nearly glabrous. Panicle 1' or more long, about as wide, the numerous slender branches spreading; spikelets obovate, apiculate, $\frac{1}{2}$''—$\frac{3}{4}$'' long, first scale minute, one-fourth as long as the nearly glabrous, 7-nerved second and third. Color of plant green, often purplish. Late stages much branched above.

Northeastern States. Specimens examined: New Jersey; Commons, 1897. New York: Wiegand, Ithaca, 1893. New York: Ashe; Watkins, June, 1898. New York: Ashe; Courtland, Aug. 1898. Maine; Merrill, 1897. Its smaller leaves, more branched panicle, and smaller spikelets separate this plant from *P. pubescens* to which it is most closely related.

66) PANICUM ANNULUM Ashe, sp. nov. Stems erect, generally single, 18'—30' high, below pilose, above generally glabrous, purple. Sheaths shorter than the internodes, at least the lower soft-pilose, nodes barbed; ligule very short, pubescent. Leaves lanceolate, 3'—4' long, 4''—6'' wide, narrowed to the rounded base, the lower pilose on the lower surface, the upper generally glab-

rous, purplish, spreading. Panicle 2'—3' long, oval, the fascicled branches spreading or reflexed; spikelets about $\frac{3}{4}$'' long, narrowly obovate, pubescent; the axis of the panicle generally viscid. The later stage much branched.

Dry rocky woods. Maryland to North Carolina and Georgia. Near Washington, D. C. Ward; 1892. North Carolina: Ashe; Chapel Hill, 1898. Georgia: Ashe; Stone Mt., 1896. Related to *P. barbulatum*, but has a smaller panicle, and is pubescent.

67) PANICUM MERIDIONALE Ashe, sp. nov. Stems 4'—8' high, densely tufted, erect or ascending, villous with ascending hairs, purplish, very leafy. Sheaths striate, villous with ascending hairs, generally shorter than the internodes; ligule pilose. Leaves numerous, erect or ascending, 1'—$1\frac{1}{2}$' long, about 2' wide, lanceolate, rounded at the base, beneath pubescent with short ascending hairs, above with a few scattered long hairs, or towards the base of the leaf villous. Panicle glabrous 1'—2' long, the branches single or a few together, ascending; spikelets elliptical or obovate, nearly $\frac{3}{4}$'' long, the first scale about one third the length of the glabrous second and third.

I have collected this species at two localities in North Carolina, Chapel Hill in June, 1898; and Jonas Ridge, Burke Co., June, 1893. As these two stations are far apart the plant probably occurs in other States to the north and south of North Carolina. Dry rocky woods. Very different from either *P. filiculme*, *P. implicatum* or *P. pubescens*.

68) PANICUM FILICULME Ashe, sp. nov. Stems tufted, or single, at first simple, later fasciculately branched above, erect, very slender, 6'—10' high, more or less villous with ascending hairs. Sheaths villous with ascending hairs, shorter than the internodes; ligule of very short pubescence or of long hair. Leaves narrowly lanceolate, $1\frac{1}{2}$' long or less, 1''—2'' wide, rounded at the base, the lower surface papillose, appressed pubescent, the upper nearly glabrous, hirsute, or merely the mar-

gins fringed with long erect hairs, the upper leaves reduced in size; secondary leaves smaller, longer than the panicles. Panicle long-peduncled, small, about ½' long, the rather short branches, erect or ascending; spikelets broadly obovate, obtuse, about ½" long.

Dry soil, middle North Carolina to Georgia in the Piedmont plateau region. Related to *P. implicatum* and *P. pubescens*. North Carolina: Ashe; Chapel Hill, 1898. Georgia: Small; Stone Mt., Aug. 1895.

69) PANICUM CILIATUM. Ell. Sk. 1:426 (1817). *P. ciliatifolium* Kth. Stems erect, 8'—16' high, smooth, slender. Sheaths smooth; ligule not hairy. Stem leaves, one to three, lanceolate, 1'—2' long, 2''--3'' wide, smooth except for the ciliate margins; basal leaves very numerous, broader and longer than the stem leaves, the entire margin ciliate with long hairs, otherwise glabrous. Panicle rather small, 1'—2' long, nearly as wide, the fascicled branches ascending or spreading; peduncles 4 to 5 times the length of the panicle, smooth, spikelets on very slender pedicels, 3 or more times their length, nearly 2" long, obovate, acute, the first scale nearly one-half as long as the smooth 7-nerved second and third.

Color pale green. Rather uncommon. Ditch banks and sandy swamps, eastern North Carolina to Florida. A beautiful species. North Carolina: Ashe; near Wilmington. 1897. Florida: Biltmore Herbarium; Apalachicola, No. 6022 a.

70) PANICUM POLYCAULON Nash. Torr. Bul. 24:200, (1897.) Stems densely tufted, 6'—10' tall, simple, nearly naked, at length somewhat branched, sheaths loose, glabrous, the margins ciliate, upper longest; ligule pubescent. Stem leaves ascending, lanceolate, the longest about 3' long, 4" wide, ciliate on the margins 7—9-nerved; basal leaves numerous, ciliate. Panicle about 1' long, its axis somewhat pilose; spikelets about ¾" long, obovate, first scale about ½' long, as the 7-nerved, glabrous second and third.

"The narrower leaves more slender culms, and smaller and glabrous

spikelets well distinguish this from *P. ciliatum* Ell., to which it is most nearly allied." Florida and Cuba.

71) PANICUM LONGIPEDUNCULATUM Scribn. Stems erect, somewhat clustered, 6'—10' high; sheaths villous with spreading hairs, or nearly glabrous inflated; ligule hairy. Stem leaves few, distant, ascending, 2"—3" wide, lanceolate, narrowed to the somewhat rounded base, soft pubescent on both sides, the margin ciliate; basal leaves rather numerous, as long and as wide as those of the stem, pubescent on both sides, ciliate on the margins. Panicle about 2' long, oval, the axis pubescent, branches fascicled, spreading, slender; spikelets obovate, barely $\frac{1}{2}$" long, obtuse, the first scale one-half the length of the smooth 7-nerved second and third, pedicels 3 to 4 times the length of the spikelets.

Color pale green. Ditch banks and wet sandy places, eastern North Carolina to Florida. North Carolina: Ashe; Roanoke Island, June, 1898. Florida: Curtiss; Jacksonville. The basal leaves of this species, like those of *P. ciliatum*, are much more prominent than the stem leaves, and the stems, having rather few leaves, appear rather naked. The autumnal stage is not fasciculately branched.

72) PANICUM MICROPHYLLUM Ashe, sp. nov. Somewhat tufted, 8'—20' high, slender, ascending or reclining, glabrous or pubescent with long white ascending hairs. Sheaths glabrous or pubescent, very much shorter than the internodes; ligule pilose. Stem leaves distant, ascending, linear-lanceolate, 1' long or less, 1"—2" wide, generally more or less villous. Basal leaves crowded, 1' or more long, 3"—4" wide. Late forms somewhat fasciculately branched above. Panicle long-peduncled, about 1' long, the slender branches ascending; spikelets, $\frac{1}{2}$"—$\frac{3}{4}$" long very broadly obovate, the minute first scale acute, one-fourth the length of the 7-nerved second and third.

Related to *P. angustifolium*. Collected by the writer June, 1898, at Chapel Hill, N. C., in moist sunny woods.

73) PANICUM BRITTONI Nash. Torr. Bul. 24:194 (1897). Stems tufted, glabrous, very slender, erect, stiff. Sheaths, glabrous, very short; ligule pubescent. Leaves longer than the sheaths, few in number, the middle leaves longest, $1\frac{1}{4}$ long or less, less than $1\frac{1}{2}$" wide. Panicle 1' long or less, branches rather few, spreading; spikelets obovate, obtuse, $\frac{3}{4}$" long, pubescent.

Moist sand, in pine woods. Southern New Jersey.

74) PANICUM GLABRISSIMUM Ashe, sp. nov. Culms very slender, 12"—20" high, tufted, erect smooth and glabrous throughout. Sheaths much shorter than the internodes, glabrous; no ligule. Stem leaves very short, distant, less than 1' long, less than $1\frac{1}{2}$" wide, narrowed to the base, erect or ascending, glabrous or sometimes with the narrowed base sparingly ciliate. Basal leaves $1\frac{1}{2}$' long or less, 2"—3" wide, ascending, glabrous. Panicle, peduncled, about 1' long, quite as wide, branches wide-spreading; spikelets, broadly oval or spheroid, about $\frac{3}{5}$" long, glabrous or nearly so, purple.

The type material was collected by me June 1898, at Manteo, Dare Co., N. C.

NATURAL SCIENCE OF THE ANCIENTS AS INTERPRETED BY LUCRETIUS.

F. P. VENABLE.

There is no work, coming from an ancient author, which gives so full a picture of the beliefs and theories of ancient times as to the physical side of nature as Lucretius'

poem *De Rerum Natura*. It is by reading this that one may get the best insight into the ancient habit of thought concerning natural phenomena and the poem can be recommended to all who are fond of tracing over again ancient by-paths and half-lost tracks.

I do not purpose in this review to deal critically with the philosophy of the poem but rather to note the explanations offered of the various natural phenomena observed. We need not boast of our great knowledge of to-day but it becomes more precious to us when we realize how painfully and slowly it has been won for us, and how through centuries of darkness we have come to clearer light.

A word or two concerning the poem itself and its author may not be amiss. Lucretius lived somewhere in the last century preceding the birth of Christ and the poem was published about the middle of that century. An Epicurean in philosophy, and a follower of the atomic school of Demokritos, his poem was written as an exposition of their systems and in their defence. It was intended to explain to the minds of men the true nature of things and free them from ignorance and superstition.

Perhaps the most striking feature of Lucretius' poem is the deep reverence shown in it for the majesty of nature. The greatest minds were those which interpreted nature and the divinest faculty possessed by man was that through which truth was discovered. Homer was to him preeminent among the poets because he was near to nature and her great interpreter.

Prof. Sellars has said of him:

"It is, however, in his devotion to truth that Lucretius more than in any other quality rises clearly above the level of his countrymen and his age. He thus combines what is greatest in the Greek and Roman mind, the Greek order of inquiry and the Roman manliness of

heart. * * * He unites the speculative passion of the dawn of ancient inquiry with the real observation of its meridian; and he has brought the imaginative conception of nature that gave birth to the earliest philosophy into harmony with the Italian love of the living beauty of the world."

This poem is, as Constant Martha calls it, the most ancient monument of the science of Rome.

Lucretius had the difficult task of transcribing the concise, dry philosophy of Epicurus into the language of a people who knew little of science and cared less for it, except in the form of some useful application, and it required great ingenuity to succeed in conveying the desired ideas in a language so deficient in the needed terms. There is perhaps no great originality shown by Lucretius in the subject-matter of the poem but his enthusiasm and intense admiration for his master made him throw his whole poetic spirit into the task and so to give life and vivacity to the dry bones of the system. With a truly Roman simplicity, as Martha says, he believed that he and his master had said the last word of science. He was confident that his theories had solved all the mysteries of the universe, many of which were after all but the creations of superstition and trembling ignorance. A similar statement is made triumphantly nearly twenty centuries later by Berthelot. In the preface to his *les Origines de l'Alchimie* he too maintains that science has done away with mystery. "*Le monde est aujourd' hui sans mystere.*" We smile at the solutions which Epicurus, through his devoted follower, offered of the phenomena of nature. Who can feel assured that some future generation shall not smile, with the same pitying superiority, over the ignorance and folly of Berthelot.

"But the old problems that have defied the thought of the ages still wait for a solution. When men inquire for

the origin of matter and how it is constituted, or for the origin of force and how it operates, the sphinx is dumb. When they attempt to get behind the phenomena of heat, electricity, magnetism, they are challenged by a sentinel they can not bribe nor force." *

On an examination of this poem the essential difference between the ancient scientific method and the present is revealed and with it the reason for much failure and little progress. Lucretius first announced his theory and then proceeded to fit it, forcibly if need be, to every fact that came within his observation. This process is reversed by the modern man of science. He first gathers his facts and from their study develops his theory. A mind already full cannot receive new truth. The emptied vessel is the only one which is ready for filling.

To the mind of Lucretius the "Universe is a real exististence and absolutely dual in nature. Body and space, or matter and vacuum, are the two essential elements admitting no third. Bodies, are therefore, made up of atoms and pores. Neither can exist where the other is. The atoms are composite, yet, paradoxical as it may seem, are solid, single, indivisible and indestructible."

> Know, then, the entire of Nature sole consists
> Of Space and Body: this the substance moved
> And that the area of its motive power.
> Know, too that bodies, in their frame consist,
> Part of primordial atoms uncombined,
> And part combined and blending: these alone
> Previous and rare; while those so solid formed
> No force create can sever, or dissolve.

Now the task which Lucretius sets himself is to take this theory and by means of it explain the formation of the material world without the introduction of any creative intelligence, the genius of man and animals, the causative forces in all the natural phenomena and even

* Harrington. Meth. Quart. Rev. 1876. LVIII. 64.

the nature of such things as heat and light and of thought itself. In fact it is concerning the "nature of things" that he writes.

Let us see first how Lucretius reasons away the difficulty that his atoms cannot be detected by the sight and so brought within the reach of examination.

Learn now of bodies which you must confess
Exist in things, but yet nowhere can see.
First when incited winds o'er ocean sweep,
Dispersing clouds, o'er whelming mighty ships,
* * * * *
Thus secret bodies sure exist in winds
Which sweep the sea, the land, the clouds of heaven.
* * * * *
So various odors we perceive in things,
Yet naught material see the organ strike.
Nor heat, nor cold, nor sounds, can eye discern,
Though all of corpor'al nature must consist,
Since they the senses strike; for know, bodies
Alone can bodies touch or touched be.

Book 5 p. 46.

Again he very beautifully impresses the lesson, which he himself so imperfectly learned, that we must reason as to causes from their visible working.

Caverns deeply worn,
Where rocks impend o'er the corroding sea,
Show not the gnawing of each breaking wave:
For Nature acts on atoms hid from sight,
In secret working, but results reveals.

Book I p. 47.

See what proof he offers as to the existence of voids in matter. This was a very essential part of his theory and it is easy to see how convincing the phenomena must have seemed to such a materialist as Lucretius:

A void exists in things.
However solid bodies may appear,
Void spaces they contain, since water drips
In caves and grots, and drops ooze out from rocks,
And all around with trickling moisture weeps
Sound traverses closed doors and solid walls
While stiffening cold strikes piercing through the limbs.
But were no void how could such bodies pass?
You needs must see it were impossible. Book 1 p. 48.

His explanation of the difference in the specific gravity of various bodies is based upon this theory of voids.

Why do some things excel in weight others
Of greater size? If equal matter be
In globe of wool and lead, why equal not
In what to matter most essential is—
Weight? Downward pressing to the void unknown,
The greater lighter than the less, thus prove
Existence of a void, the heavier still
Embracing less than light of spaces void.

Book I p. 49.

From his standpoint the weight was dependent upon density or compactness. From this is it might be inferred that all atoms had the same weight.

The beautiful phenomenon of the condensation of moisture upon a cold surface is correctly explained if we disregard the description of a material nature and separate existence to cold.

Cold permeates the silver cup or gold,
With water filled, held brimming in the hand,
And dew-like moisture gathers on without.
Thus naught in nature solid seems to be.

Book I p. 53.

The doctrine of the indestructibility of matter has been commonly accredited to Lavoisier but a recent writer has shown that the saying attributed to him "*Rien ne se perd et rien ne se crée*" does not occur in his works and that at best he tacitly assumed this which had long been believed by others. Kahlbaum traces it to P. Mersenne the friend of Descartes but, it is easy to go many centuries back of this and to find the doctrine clearly stated in Lucretius. He writes of his atoms:

Nature reserving these as seeds of things,
Permits in them no minish nor decay;
They can't be fewer and they can't be less.

Book 1 p. 57.

Or again:

Decay of some leaves others free to grow
And thus the sum of things rests unimpaired

Book II p. 79,

And again:

The store of elements material,
Admits no diminution, no increase;

Book II p. 86.

No modern scientific man could state more clearly than Lucretius does, the ideas which prevail at present as to the motions of the atoms. Says Tyndall of the particles in a mass of iron: "There is space between them, they collide, recoil, they oscillate."

The poet states it thus:

No place of rest is found
To primal bodies through the vast profound,
And, finding none, they cease not ceaseless rounds.
Part forced together, wide asunder leap;
From closer blow part, grappling with their kind,
In close affinities unite and form
Bodies of various figure—varied forms diverse.

Book I p. 80.

Again:

For infinite atoms, in a boundless void,
By endless motions build the frame of things.

Book II p. 82

All things are made up of these atoms:

The same elements constitute the air,
The sun, the earth and animals and plants,
And other things by union various.

Book I p. 63.

Lucretius makes much use of what he calls the "seeds of heat," that is, the atoms which by their concurrence form heat. Thus he explains the heat resulting from friction.

The neighbor top of trees swayed by the wind
Are creaking rubbed, till by attrition they
Burst into flower of flame; not that the fire
Dwells in the wood but rather seeds of heat

By friction forced to flow, together run,
And bursting barriers fire the leafy tops.
For sure, if latent lay the flames in wood,
Not long could they be hid, but, bursting forth,
Would ravage forests, burning every shrub

Book I p. 63.

He is an avowed opponent of the ordinary view of gravitation. In common with his countrymen, he thought lightly of mathematics.

Guard agaist belief
Of what some say, "that to the centre tend
All things, and thus the world can stand
Without external impulses and shocks."—BookI, p 71.

Are we to look upon the following passage as a prediction of the discovery of argon and its strange companions? Speaking of his atoms he says :

And some there are wide wandering in space,
That all affinities reject, nor can unite
With any body in a common bond.—Book II p. 81.

He puzzles over one of our deep problems, the co-existence of sovereign law and the free will of the creature.

Again, if all motion in a chain were bound,
If new from old in fixed order flowed,
Cause linked to cause in an eternal round;
If atoms no concealed clinamen had
Cause to create, and break the bond of fate,
How could free-will in animals exist?

In speaking of the dissimilarity in atoms he discusses the nature of fire and cold. His conclusions are somewhat startling :

How different is fire from piercing frost!
Yet both composed of atoms toothed and sharp
As proved by touch. Touch, O ye sacred powers!
Touch is the organ whence all knowledge flows:
Book II p. 90

His theory as to the three physical states is that solids are made "of atoms hooked like branches deep entwined"; liquids, "of bodies round and smooth must be composed";

"while those that in an instant are dispersed, and flee away, as smoke, or clouds, or flame," are formed of "sharp and not of atoms hooked since pores they penetrate."

The dependence of color upon light is well recognized "without light no color can exist." Atoms are colorless and not subject to the rays of light,

He has noted that

> The more minutely things divided are
> The more their colors fade.

He has observed that light traverses space more rapidly than sound,

> Far quicker comes the impulse to the eye
> Than to the ear:
>
> Book VI p. 263.

There is an interesting passage in the works of Van Helmont in which he describes the artificial generation of mice from a soiled shirt placed along with some flour in a barrel or other vessel. The method sounds plausible and doubtless an experiment along that line would result in mice in the barrel. But too much credit must not be ascribed to Van Helmont as the original discoverer for after all his ingenious idea was not original. Our poet of the last of the old centuries says;

> Facts manifest
> Confute not but confirm and force belief,
> That all the living from the lifeless springs;
> For see live worms creep from the putrid clod,
> When the warm earth is wet with timely showers.
>
> Book II p. 106.

Darwin might have gotten an idea or two from our ancient philosopher for his "Observations upon Earthworms".

Lucretius' ideas as to life, disease and death are also instructive. Men of deeper learning than he have wrestled with this problem of Life and Death with equal

failure. The best of modern thought agrees with him in one sense at least when he says:

"And life itself is but a part of death."

Death he believes comes from some shock which shatters and destroys the union of the atoms. The shock theory of fermentation and decay was vigorously maintained and defended during the first half of this century.

Then when some greater shock a life assails
Than Nature can support, sudden all sense
Of mind and body is confused and stunned.
The ordering of elements dissolved,
Their bond of union snapped, the silver cord
Is loosed, the vital tide turned back, and life
With all its elements dispersed. But what
Can blows do more than shatter and dissolve
What once was joined?

Book II p. 108

Liebig in 1852 reasoned that contagion was due to gaseous matter in a state of decomposition. Disease is excited by contagion. According to the "law of La Place and Berthollet: *A molecule* set in motion by any power can impart its own motion to another molecule with which it may be in contact. The motion of these decomposing molecules is transmitted to the blood and if decomposition there is not overcome it proceeds over the entire body." This reads almost as strangely as the words of Lucretius. It is only just to Liebig to add that he acknowledged his errors afterwards and accepted the theories of Pasteur and Schützenberger.

Lucretius' theory of contagion would sound very much like the modern germ theory if only his seeds were endowed with life.

First, then the air teems, as I've taught, with seeds
Diverse, some favoring life, but many more
Fraught with disease and death; chance gathered, these
Infect the sky, malignant make the air.

Lucretius has anticipated the recent address of Sir

William Crookes, the learned President of the British Association for the Advancement of Science, by more than nineteen centuries in the prediction of the exhaustion of "the worn-out Earth." True he did not fix upon 1931 as the date of complete exhaustion still he evidently did not think it very far off. Like all sturdy conservatives he praised the good old times.

E'en now the worn-out earth with age effete,
* * that in her early prime * * *
To children of her care spontaneous gave—
In rich abundance gave the shining grain,
Which now with labor huge she scant supplies
In niggard pittance to more pressing wants,
With weary steps we urge the weary ox,
And turn exhausted fields, that scarce return
Decreasing harvests to increasing toil.
The aged ploughman shakes his weary head
So oft his labor unavailing proves:
How oft doth he then repining chide his lot
Comparing present times with past, exalt
The fortune of his sires.

Book. II p. 114.

He gives a remarkable explanation of the nature of reflected images. These are made up of

Thin effigies and forms
Which singly are unseen; but when outpoured
In a continuous and impulsive flow,
Give by reflection, images of things.

These effigies "wander not alone." They "fill the embracing air with floating forms." This is proved by the fact that in whatever direction the mirror is turned, "straight in its silent depths the scene responds." The reversal of the image in the mirror is explained at some length. The image itself suffers change on turning back from the mirror.

As when the plastic mask of wax, or clay,
, Dashed sudden 'gainst a wall, backward reverts,

The well-recognized law that the angle of reflection is equal to the angle of incidence comes from Lucretius thus:

For with what slope
They fall, Nature compels them to revert again.

Peter Schlemihl, the famous shadowless man of Chamisso would have been wondrously relieved if he could have read Lucretius and learned,

The obsequious shadow that attends our steps,
When walking in the sun seems of itself
To walk with us and every gesture mock
Yet nothing is but space, deprived of light

Book IV p. 169.

If we accept Lucretius' theory that "all sounds corporeal are," then it is easy to account for prevalent sore throats·

And voice escaping to the sphery air,
Roughens the throat, abrades the passages,

"Whence come our mental images" is surely a most important question to settle but one before which the boldest is apt to hesitate.

There is no such hesitancy about Lucretius, however. "Innumerable idols float in space." These are many subtle and of finer texture than the "attenuate thread of spider or the roof of filmy gold." These

Through rarer pores can penetrate.
And sentient make the mind in inmost seats.

Book IV p. 181

Any one inclined toward materialism can read with interest the intense materialism of this old Epicurean. His cosmogeny is brilliantly fanciful. As to the sun it is neither greater nor less than it appears and this is true also of moon and stars. Whether the sun returns by a course beneath the earth or whether it is exhausted by its day's course and its place is taken by a new one, formed by the collection of "dispersed seeds of heat" he does not venture to decide. Eclipses and the moon's phases are also discussed. The struggle for existence is pictured and something very similar to the doctrine of the survi-

val of the fittest is announced. Thunder is the rushing together of several clouds "driven by warring winds." The nature of clouds he discusses at great length. Some of these phenomena have puzzled men all through the ages and it is not nccessary to point out how imperfect our knowledge still is.

The interior of the earth is constituted as the surface and hence contains caves. lakes etc. The falling in of such caverned depths cause the earthquakes. In these caverns the air in motion "makes glow the rocks around." Winged flames then "vomit from wide open jaws" hurl rocks, and send out cinders and smoke, and so volcanoes are formed. The constancy of the volume of the sea was observed by Lucretius and correctly accounted for.

A strangely mistaken observation as to the temperature of wells is mentioned and of course his theory is made to cover and explain it. Such waters were thought to be cold in summer and warm in winter. This was, of course because what we may call the personal thermometer registered largely the relation to the temperature of the atmosphere.

I have not been able to exhaust all of the observations recorded by this early philosopher, nor to properly show his ingenuity in fitting his theory as to atoms and the "seeds of things" to every case. Nor has it been possible to give a just idea of the grace and poetic beauty of this the first and only attempt to bring all of natural science within the limits of a single poem.

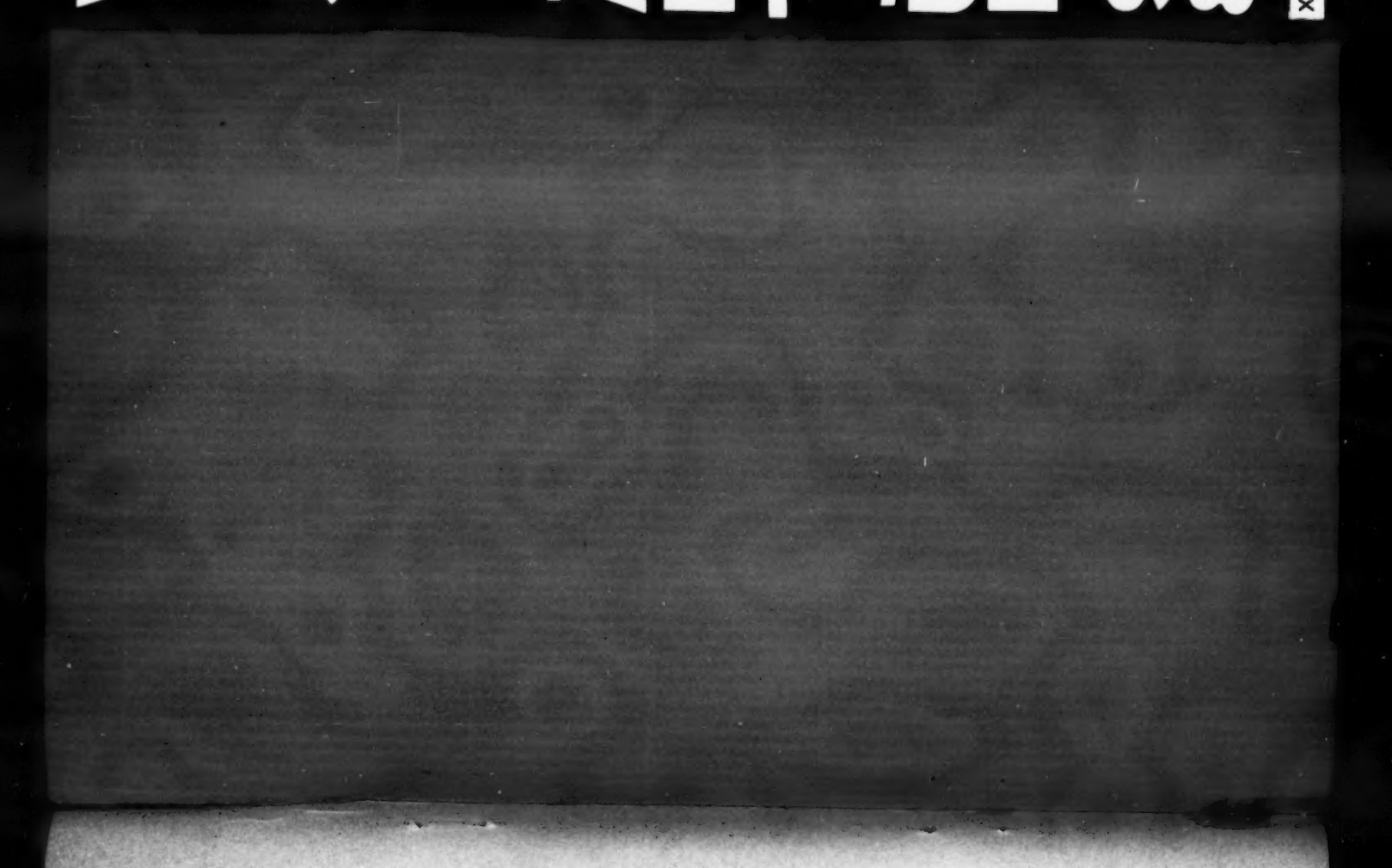
WORKS CONSULTED IN THE PREPARATION OF THIS ARTICLE.

1 T. Lucretii Cari, De rerum natura, ex editione Gibb., Wakefieldi. Valpey's auctores classici.

2 Lucretius, On the Nature of Things. A philosophical poem, translated by Rev. John L. Watson, with the metrical version by John M. Good.

3 Lucretius, On the Nature of Things. Translated into English Verse by Charles Frederick Johnson. The passages quoted are taken from this work.

4 Le Poème de Lucréce, Morale, Rcligion, Science par Constant Martha.

5 The Atomic Theory of Lucretius contrasted with Modern Doctrines of Atoms and Evolution, by John Masson.

6 Lucretius, by Prof. Harrington, Methodist Quarterly Review- 1876, p. 64.